CHAPTER 20
APPLICATION NOTE 969

Economic, High Performance, High Efficiency Electronic Ignition with Avalanche-Rated HEXFET®s

(HEXFET is a trademark of International Rectifier)

by Brian E. Taylor

Introduction

Gasoline engine ignition circuits represent a severe environment for semiconductor switches. A transistor used in place of the traditional mechanical contact breaker is called upon to block high voltage at the moment it interrupts the coil current. Bipolar transistors, with a susceptibility to second breakdown, have found this a difficult situation in which to perform reliably. Power MOSFETs, on the other hand, having no second breakdown limitation, are ideally suited to this role and do not require the use of snubbers for load-line shaping.

International Rectifier's HEXFET III power MOSFETs are especially well suited to this application since they can tolerate high levels of energy in avalanche breakdown. Overvoltage produced at turn-off by the coil leakage inductance or excessive primary coil voltage resulting from a disconnected high tension lead can both be clamped by avalanching of the HEXFET (Ref. 1).

The advantages of the HEXFET which make it a particularly suitable device for use in electronic ignition systems are:

- High reliability
- Square Safe Operating Area
- Voltage control
  (no base drive required)
- Avalanche capability

The suitability of power MOSFETs for this application has sometimes been overlooked because of concern over the resistance of the MOSFET due to the high voltage rating required by the application. In fact, as this application note shows, an ignition system using a HEXFET as the switching device can meet all the necessary specifications, including performance at crank voltage, with a higher efficiency than that typically encountered in systems employing a bipolar transistor.

Electronic Ignition

The introduction of electronic ignition — initially as an "after sales add-on" — was instigated as a means of overcoming the inherent weaknesses of the mechanically switched system as utilized with the Kettering distributor. Improved overall performance was the justification for the high initial purchase price.

The earliest electronic ignition systems were invariably capacitor discharge (CDI) systems, and for very good reasons: the standard ignition coil, as fitted by the car maker, was retained. Inductive discharge (ID) systems, at that time, were not possible without a change of ignition coil. This was fundamentally due to the lack of high voltage power switching transistors. When high voltage power bipolar transistors became readily available at an economical price, inductive discharge systems (with the standard ignition coil) proved to be a reality.

Unfortunately by then the standard coil had been discarded by the car maker in favor of low inductance coils with ballast resistors in order to obtain improved cold starting. The bipolar transistor was therefore called upon typically to switch 6 amperes. To do so with relative reliability, safe operating area clamps were used, raising both cost and dissipation. HEXFETs, being majority carrier devices, are not subject to second breakdown, and therefore do not require safe operating area clamping.

Ignition modules of today have not changed dramatically, although as this application note demonstrates, higher efficiency could be achieved, without any sacrifice in performance, with a lower current, high inductance coil.

Ignition Requirements of Modern Gasoline Engines

These requirements can be quantified into four distinct categories: (i) Aiming voltage at the sparking plug; (ii) Available energy from the coil; (iii) Spark duration; (iv) Crank voltage. Besides these four major categories there are several others, including efficiency, reliability and cost.

i) *Aiming Voltage*

This requirement may be defined as the open circuit voltage available at the high tension terminal of the coil prior to the interelectrode gap of the sparking plug breaking down. This voltage should not be confused with the "arc voltage" developed across the gap of the sparking plug after breakdown. The aiming voltage is frequently specified as 16 kilovolts at a minimum battery voltage of 13.2 volts and is derived from measurements originally made with contact breaker systems. It is desirable that the aiming voltage be as high as possible (without endangering

coil winding insulation) in order to successfully "fire" fouled plugs. Simplistically, aiming voltage (Va) may be expressed as:

$$V_a = i_p \cdot \sqrt{L_p/C_s} \quad (1)$$

where Lp is the inductance of the primary (low tension) winding, ip is the peak instantaneous current flowing in the winding when the power switch "opens" and Cs is the interwinding capacitance of the high tension winding.

(ii) *Available energy from the coil*

The minimum value required can be demonstrated to be less than 2 millijoules. Specifications for engines frequently quote a value of 6 millijoules for a crank voltage of 6 volts. Extrapolation for crank voltages of 4.5 volts gives a minimum energy of 4 millijoules. It should be remembered that too high an energy level will accelerate spark plug electrode erosion.

The coil energy may be found from:

$$E_{coil} = \tfrac{1}{2} L_p \left(\frac{V_b}{R_{coil} + R_{SW}} \right)^2$$

(iii) *Spark duration*

Many variables determine the requirements of this parameter. These may be listed as follows:

a) The number of cylinders
b) Maximum revolution rate of the engine
c) Fuel/air mixture in the combustion chamber
d) Static ignition timing at engine idle

Consider an eight cylinder engine running at 6000 revolutions/minute. The maximum time interval between the commencement of one spark and the next approximates to 2.5 milliseconds. The crankshaft angular velocity is 360 degrees in 10 milliseconds, or 1 degree in 27.8 microseconds. Centrifugal advance can be up to 21 degrees Before Top Dead Centre (BTDC). Frequently quoted spark durations for CDI of 400 microseconds are normally considered adequate. If the dwell time is 1.8 milliseconds maximum, then a spark duration of 700 microseconds should be perfectly adequate to avoid detonation due to premature extinguishing of the flame front.

On the other hand, consider the same engine at idle (800 revs/min). The maximum time interval between the commencement of one spark and the next approximates to 18.75 milliseconds. The crankshaft angular velocity corresponds to 360 degrees in 75 milliseconds or 1 degree in 208 microseconds. The spark advance at static idle may be 6 degrees BTDC. The 400 microsecond spark duration of CDI seriously enhances the possibility of detonation due to premature extinguishing of the flame front upon cessation of the spark. This phenomenon is more likely to occur in modern fuel efficient (lean burn) engines. Volt-second product balance for the ID system should provide a spark duration at idle long enough to prevent detonation.

(iv) *Crank voltage*

This voltage may be defined as the available battery voltage during operation of the starter motor — that is, the cranking voltage. Various specifications for 12 volt cars place this voltage at 6.0 volts and in some instances as low as 4.5 volts (worst case).

A bipolar Darlington transistor and a 4 mH coil (limited to 6 amperes) will provide an aiming voltage of 12 kV. An 8 mH coil (limited to 3.5 amperes) with a HEXFET, such as the one described in this application note, will provide an aiming voltage of 13 kV. Therefore, both systems perform equally well in this respect, with the HEXFET system consuming less power and, therefore, providing higher efficiency.

Design of a HEXFET Ignition System

All the requirements previously encountered can all be easily fulfilled, but not necessarily optimized in terms of performance, cost and efficiency. A bipolar Darlington transistor with an 8 mH coil would only generate an aiming voltage of 9 kV at a crank voltage of 4.5 volts. This may be insufficient to "fire" the plugs. The 4 mH coil and Darlington transistor would be adequate for the crank voltage of 4.5 volts but power consumption would increase, as will be demonstrated.

The first priority is to select a coil with as low a primary current as possible (commensurate with the minimum energy requirements of the system). The coil primary inductance should be 8 millihenries (nominal). The primary resistance should not be less than 2.5 Ohms and not greater than 3.75 Ohms. The turns ratio of the coil should be a nominal 55:1.

The HEXFET for the power switch should ideally be an IRF741. This device will give maximum clamped aiming voltages of 19 kV for minimum BV_{DSS} and 21 kV for maximum BV_{DSS}. (Aiming voltages are quoted for open circuit HT terminal.) These aiming voltages will not cause internal breakdown in the coil. HEXFET data sheets specify a minimum value of BV_{DSS} but not a maximum value of BV_{DSS}. The maximum BV_{DSS} assumed here is the minimum BV_{DSS} of the prime voltage version of the IRF741, the IRF740.

The combination of coil and HEXFET described above would give the following theoretical performance figures:

1. Aiming voltage during cranking (at 4.5 volts): 10 kilovolts minimum.
2. Spark energy during cranking (at 4.5 volts): 4.7 millijoules (specified minimum typically 4 millijoules).
3. Spark duration during cranking: 150 microseconds minimum (low cost CDI systems have spark durations of 150 microseconds).
4. (a) Maximum power consumption = 17 watts at 6000 RPM, 8 cylinder engine (32 watts for 4 mH coil and Darlington bipolar transistor).
   (b) Maximum power consumption = 25 watts at 800 RPM, 8 cylinder engine (42 watts for 4 mH coil and Darlington bipolar transistor).

Practical Circuit and Performance

The schematic of Figure 1 shows a practical ignition module with built-in test oscillator composed of R1, R2, R3, C3 and half of IC1. This oscillator provides a 50 Hz, 50% duty cycle pulse to the base of Q2, with S1 open. With S1 closed, normal ignition triggering is via the IGNITION INPUT (input high for Q6 off).

Q1, D2, D3, C6, C7 and the second half of IC1 comprise a gated "charge pump" for maintaining adequate gate voltage for Q6, for battery voltages less than 10V (during cranking). Q6 avalanches repetitively and absorbs the energy stored in the leakage inductance of the coil. Table 1 provides the component listing for the schematic of Figure 1.

Table 2 gives details of the performance unit. The minimum available energy at 4.5 volt (crank voltage) is a healthy 5.92 millijoules against a requirement of 4.7 millijoules.

Photograph 1 shows the waveforms of HT voltage (upper trace: 5 kV/div) and drain source voltage across Q6 (lower trace: 100V/div). The battery voltage is 4.5 volts and the HT terminal is unterminated. It would appear that the spark duration would work out at approximately 150 microseconds (the time base is 100 microseconds/div), but as the waveforms in photograph 2 demonstrate is somewhat longer in practice.

1H6 400V $\frac{1}{2}CV^2$ $\cdot 10^{-6}$ 16/10 / 2 $8\cdot10^{-2}$

TABLE 1: ELECTRONIC IGNITION MODULE — COMPONENT LIST

C1 — Capacitor metallised polycarbonate 2.2 microfarad 100V D.C. working
C2 — Capacitor metallised polycarbonate 10 nanofarad 100V D.C. working
C3 — Capacitor metallised polycarbonate 0.1 microfarad 100V D.C. working
C4 — Capacitor metallised polycarbonate 10 nanofarad 100V D.C. working
C5 — Capacitor metallised polycarbonate 10 nanofarad 100V D.C. working
C6 — Capacitor metallised polycarbonate 0.1 microfarad 100V D.C. working
C7 — Capacitor metallised polycarbonate 0.1 microfarad 100V D.C. working
C8 — Capacitor ceramic 2.2 nanofarad 1KV D.C. working

D1 — Zener 9.1V 200 mW
D2 — 1N4001
D3 — 1N4001
D4 — 1N4148
D5 — Zener 15V 200 mW

Q1 — 2N2369
Q2 — 2N2369
Q3 — 2N2369
Q4 — 2N2369
Q5 — 2N2905

R1 — Resistor 100K 1/8W
R2 — Resistor 100K 1/8W
R3 — Resistor 39K 1/8W
R4 — Resistor 2K7 1/8W
R5 — Resistor 2K7 1/8W
R6 — Resistor 5K6 1/8W
R7 — Resistor 10K 1/8W
R8 — Resistor 820R 1/8W
R9 — Resistor 1K 1/8W

R10 — Resistor 5K6 1/8W
R11 — Resistor 10K 1/8W
R12 — 820R 1/8W
R13 — 12R 1/8W

IC1 — ICM 7556

S1 — Switch SPST

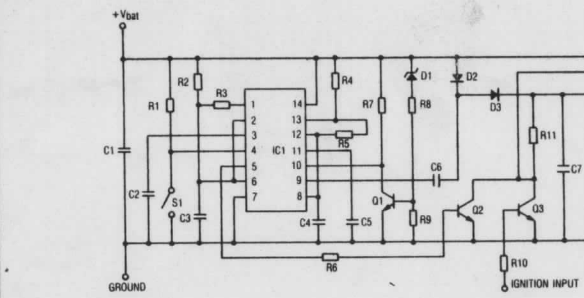


FIGURE 1 ELECTRONIC IGNITION MODULE

7,6500
7,6
.76·10 1
.38mJ

TABLE 2: PERFORMANCE OF STANDARD (6 mH NOMINAL 3.2 AMPERE) COIL SWITCHED BY IRF740

BATTERY VOLTS	EHT VOLTS (KILOVOLTS)	BRIDGEABLE AIR GAP HT TERMINAL OPEN (MM/INS)
4.5	11.0	5.0/0.197
6.0	14.0	8.5/0.335
12.0	23.5 (NOTE 1)	13.0/0.512 (NOTE 2)
14.0	26.0 (NOTE 1)	16.0/0.63 (NOTE 2)

NOTES:

1: Minimum measured value with stable oscilloscope trace.

2: Audible and visual (oscilloscope)
Evidence of coil internal breakdown

In photograph 2, the time base has been changed to 200 microseconds/div and the lower trace sensitivity to 200V/div. The upper trace sensitivity remains at 5 kV/div. The waveforms show the gap breaking down at approximately 9 kilovolts, while the arc sustaining voltage is approximately 2 kilovolts. From the lower trace it is evident that the spark duration is approximately 200 microseconds for a maintained battery voltage of 4.5 volts.

Photograph 3 shows the waveforms obtained with the bridgeable air gap set to 12 mm and the battery voltage set to 14 volts. This would be the minimum voltage during charging that would be seen as a typical condition in the car.

The HT waveforms appear on the upper trace (5 kV/div) while V_{DS} of Q6 is on the lower waveform (200 V/div). It can be seen that the gap breaks down at approximately 16 kilovolts while the arc is maintained for approximately 1 millisecond. The 500 V drain source spike is caused by the leakage inductance of the coil and plays no part in the spark generation. This is vividly demonstrated in photograph 4 where the time base speed has been increased to 1 microsecond/div.

It can be seen from photograph 4 that the HT voltage has only reached about 2 kilovolts by the time the leakage reactance spike starts to diminish. The magnitude of the leakage spike amply displays avalanche occurring in the HEXFET, and this avalanche capability will prevent the HT voltage from ever exceeding a nominal 22 kilovolts with an IRF741 for Q6. It is worth noting that the waveforms in all photographs were obtained at a frequency compatible with an engine RPM of

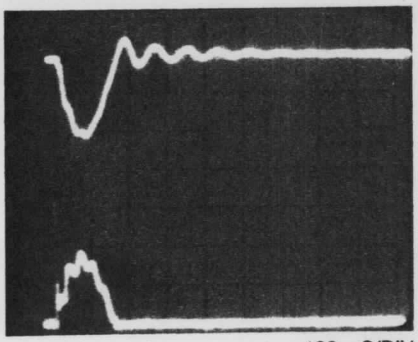


Photo 1

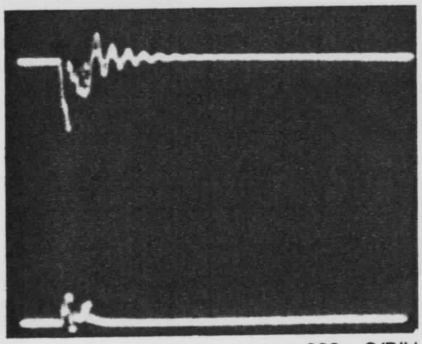


Photo 2

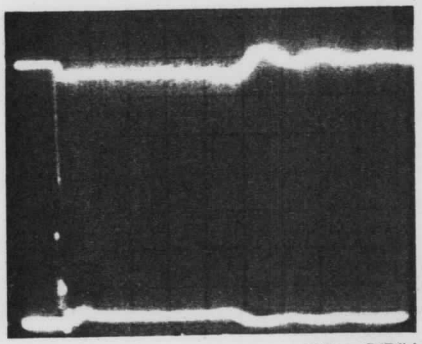


Photo 3

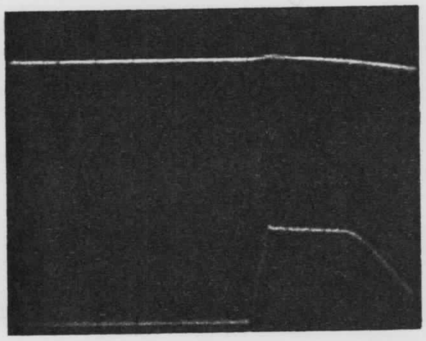


Photo 4

6000 for an 8 cylinder engine. At idle the increased dwell angle would certainly increase the magnitude of the HT aiming voltages of photographs 1 and 2.

The maximum power consumption measured at 800 RPM and 6000 RPM was 21.5 Watts and 16.8 Watts, respectively, and is in line with the design specification.

Conclusion

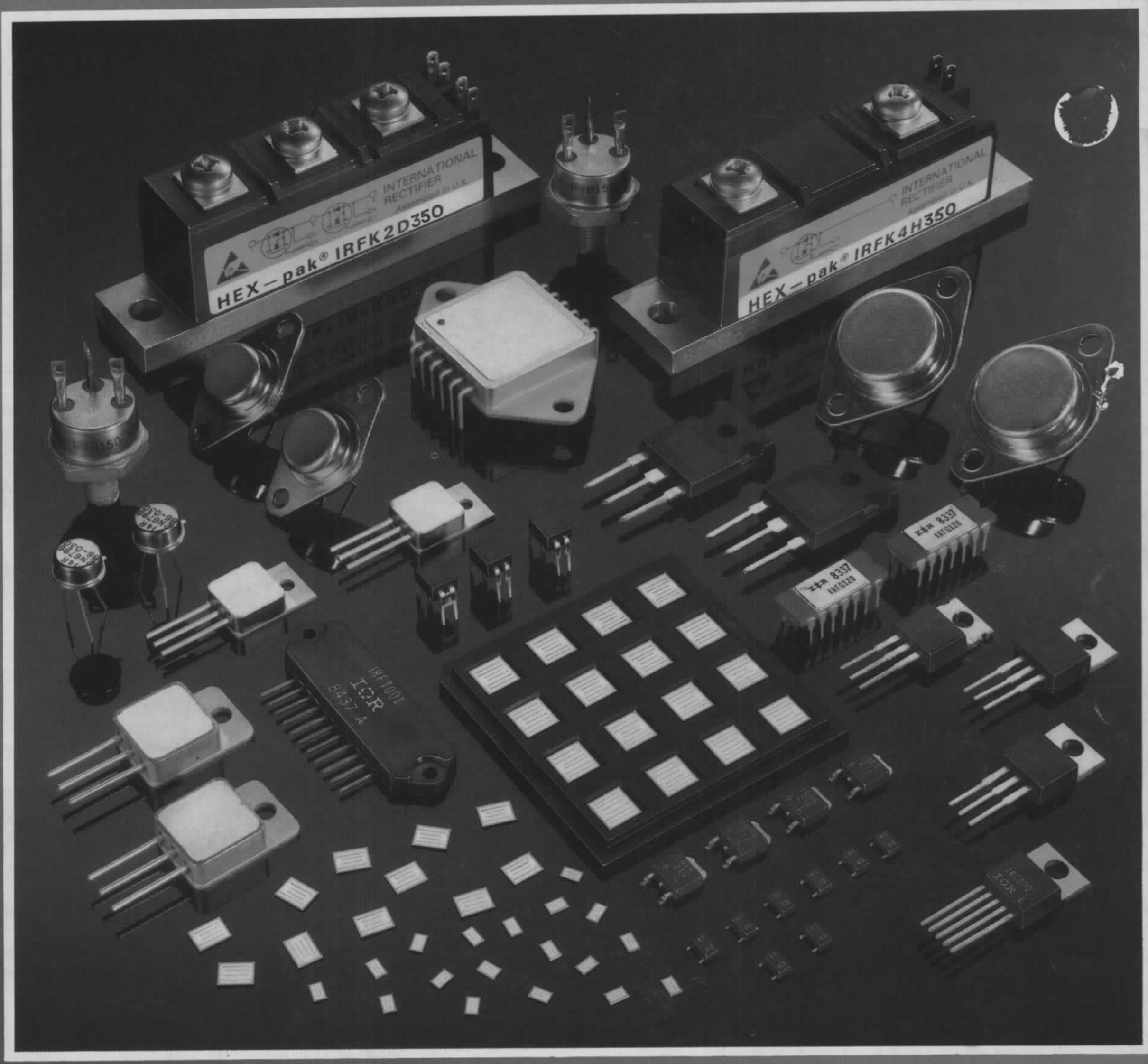
The ignition module of Figure 1 gives a performance similar to that of any of the better systems available today without any sacrifice in cost. It provides worthwhile savings in power consumption and generated heat, this last factor ultimately being a measure of reliability. □

References

(1) International Rectifier Application Note AN966: HEXFET III — A New Generation of Power MOSFETs.

Selection Guide E1003G

INTERNATIONAL RECTIFIER



HEXFETS®

The HEXFET® IRel Programme

Facts to prove that HEXFETs are the most reliable power Semiconductor

The **IRel** program for HEXFETs continuously monitors reliability. The results of unprecedented comprehensive tests have been published and are updated regularly in HEXFET **Quarterly Reliability Reports.** (Available to customers upon request.)

Failure rate information is guaranteed and enables the users to predict the reliability of HEXFETs in their circuits. Typical graphs are shown below which are valid for the specific HEXFET ranges indicated.

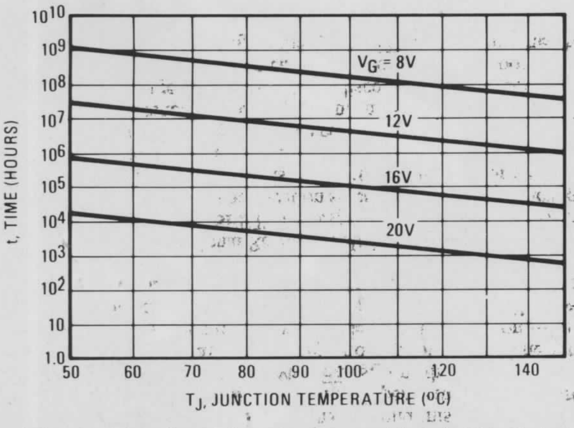


Fig. 1 — Typical Time to Accumulated 1% Gate Failure, All Devices.

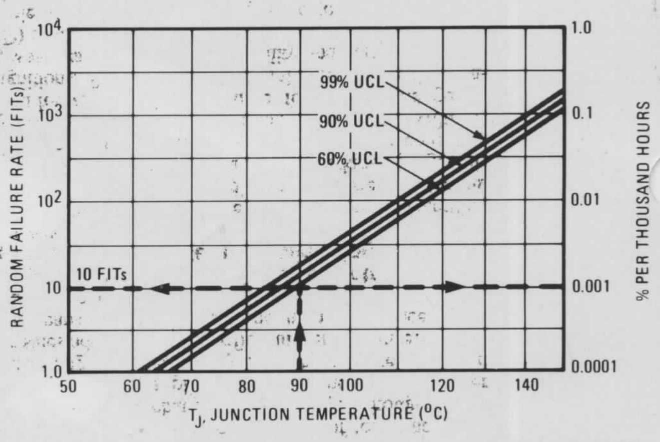


Fig. 2 — Typical High Temperature Reverse Bias (HTRB) Failure Rate, TO-220AB Devices.

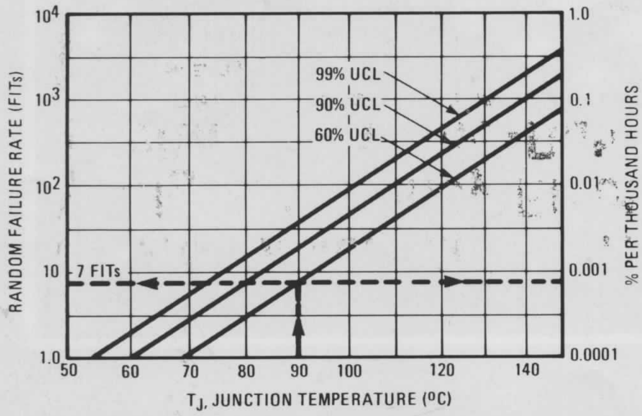


Fig. 3 — Typical High Temperature Reverse Bias (HTRB) Failure Rate, HEXDIP® Devices.

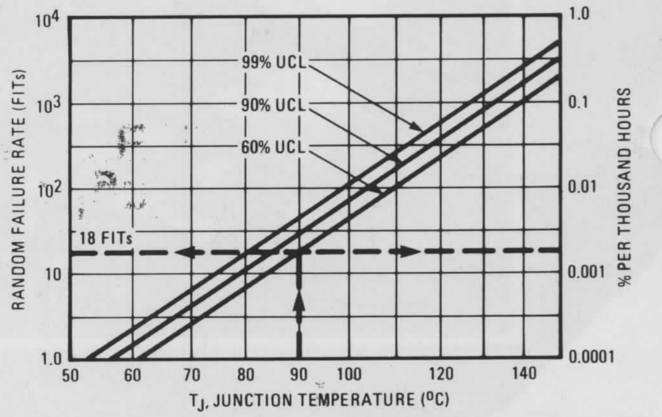


Fig. 4 — Typical High Temperature Reverse Bias (HTRB) Failure Rate, TO-3 Devices.

The data presented above is the result of testing conducted through January 15, 1985. Further accumulation of test data will allow the presentation of even lower failure rates.

MTBF (mean-time-between failure) of over 20,000 years at 70°C — i.e., failure below 0.6% per 1,000,000 hours (yes, one million!!) — are consistently recorded in the **IRel** program.

Lot Traceability is maintained not just for military but all commercial devices as well. In the unlikely event of a failure, identity and history can be traced back to the starting materials and can be checked against a control sample kept from the original lot.

A reliability certification is performed on each lot as shown below.

These tests have demonstrated that our infant mortality rate is the lowest of any power semiconductor.

Reliability Certification — Accelerated Tests

TEST SAMPLE	SIZE	REJECTION	PURPOSE
HTRB T_J = 150°C t = 12 hours	50	1	Detect temperature dependent failure modes and any change in performance parameters with temperature.
GATE STRESS T_J = 150°C t = 2 hours	50	1	Check the reliability of gate oxide and oxide/silicon interface.

Reliability Certification — Destructive Tests

TEST SAMPLE	SIZE	REJECTION	PURPOSE
SOA FAILURE POINTS	10	1	Check power handling capability.
GATE DIELECTRIC STRENGTH	10	1	Check oxide integrity.
AVALANCHE ENERGY	10	1	Check ability to handle inductive overloads.
THERMAL RESISTANCE	10	1	Check integrity of header/solder/die interface.

Life tests are run on a continuing basis to insure long term reliability as shown below.

RELIABILITY REPORT — LONG TERM TESTS

TEST	CONDITIONS	PURPOSE
85/85 (plastic packages)	V_{DS} = 10V 85% relative humidity 1000 hours T_J = 85°C	Check ability of non-hermetic packages to operate with bias in high relative humidity.
Power Cycling	ΔT = 70K	Determine number of power cycles the package/solder/die combination can withstand.
HTRB	80% V_{DS} V_{GS} = 0	Determine failures per 1000 hrs. for each failure mode and temperature dependent activation energy.
Long Term Gate Stress	V_{GS} = +20V T_J = 150°C	To detect random oxide defects affecting the Infant or Random failure rate ragions.
Temperature Cycling	ΔT will vary depending on objective.	Similar to power cycling test and will also determine package/wire bond/solder/die capability.
Pressure Cooker with and without bias (plastic packages)	121°C 100% RH (15psig)	To accelerate humidity degredation effects and to compare with the 85°C/85% RH test.

HEXFET Reliability

Features that make HEXFETs the most reliable power Semiconductor

SUPERIOR DESIGN

No wire bonds on active area; solder mounted chips; guard rings for higher voltage devices; all dice are passivated; stress relieved packaging of plastic devices.

BEST ELECTRICAL PROGRAMME

HEXFET $R_{DS(on)}$ ratings are the lowest per unit area. This insures lower junction temperatures at high drain currents, thus HEXFETs exhibit superior reliability.

TIGHTER PROCESS CONTROL

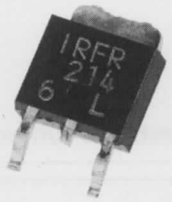
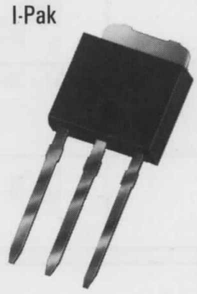
The seven-stage process control/engineering feedback loop ("Seven Sisters") used in HEXFET production is the most advanced manufacturing control system today. It uses extensive computerization and communication between stages to eliminate problems before they can affect outgoing quality.

OUTSTANDING QUALITY

While HEXFETs are guaranteed to an AQL of 0.04% on all parameters, the outgoing quality level (AOQL) is actually less than 200 parts per million defective. This enables IR to offer customers a Total Quality Partnership (TQP) program which eliminates costly qualification and incoming inspection.

HEXFET™ Surface Mounted Packages

N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFS1Z0 IRFS1Z3	100 60	2.4 3.2	0.90 0.75	3.5 2.5	3.5 3.5	PD-9.438 PD-9.438	TO-243AA (SOT-89) 
IRFR224 IRFR214	250	1.10 2.00	3.8 2.0	15.2 8.0	40 20	–	TO-252AA D-Pak 
IRFR220 IRFR210	200	0.80 1.50	5.0 2.5	20.0 10.0	40 20	–	
IRFR120 IRFR110	100	0.30 0.60	8.0 4.0	32.0 16.0	40 20	–	
IRFR121 IRFR111	80	0.30 0.60	8.0 4.0	32.0 16.0	40 20	–	
IRFR020 IRFR010	50	0.10 0.20	15.0 7.2	60.0 28.8	40 20	–	
IRFU224 IRFU214	250	1.10 2.00	3.8 2.0	15.2 8.0	40 20	–	TO-251 I-Pak 
IRFU220 IRFU210	200	0.80 1.50	5.0 2.5	20.0 10.0	40 20	–	
IRFU120 IRFU110	100	0.30 0.60	8.0 4.0	32.0 16.0	40 20	–	
IRFU121 IRFU111	80	0.30 0.60	8.0 4.0	32.0 16.0	46 20	–	
IRFU020 IRFU010	50	0.10 0.20	15.0 7.2	60.0 28.8	40 20	–	

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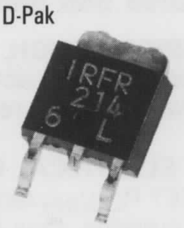
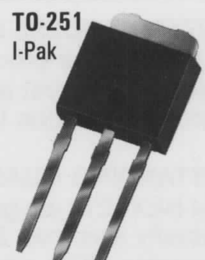
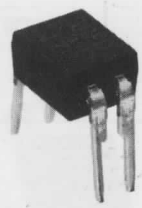
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFR9220 IRFR9210	-200	1.50 3.00	-3.50 -1.75	14.0 7.0	40 20		TO-225AA D-Pak 
IRFR9120 IRFR9110	-100	0.60 1.20	-6.00 -3.00	24.0 12.0	40 20	–	
IRFR9121 IRFR9111	-80	0.60 1.20	-6.00 -3.00	24.0 12.0	40 20	–	
IRFR9020 IRFR9010	-50	0.28 0.50	-9.70 -4.70	35.8 10.0	40 20		
IRFU9220 IRFU9210	-200	1.50 3.00	-3.50 -1.75	14.0 7.0	40 20		TO-251 I-Pak 
IRFU9120 IRFU9110	-100	0.60 1.20	-6.00 -3.00	24.0 12.0	40 20		
IRFU9121 IRFU9111	-80	0.60 1.20	-6.00 -3.00	24.0 12.0	40 20	–	
IRFU9020 IRFU9010	-50	0.28 0.50	-9.70 -4.70	38.8 18.8	40 20		

HEXFET™ HEXDIP™ Package

N-CHANNEL

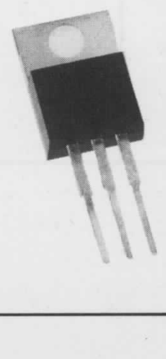
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFD220	200	0.8	0.8	6.4	1.0	PD-9.417	**HD-1** Similar to MO-001AN
IRFD210		1.5	0.6	2.5	1.0	PD-9.386	
IRFD223	150	1.2	0.7	5.6	1.0	PD-9.417	
IRFD213		2.4	0.45	1.8	1.0	PD-9.386	
IRFD120	100	0.3	1.3	5.2	1.0	PD-9.385	
IRFD110		0.6	1.0	8.0	1.0	PD-9.328	
IRFD1Z0		2.4	0.5	4.0	1.0	PD-9.380	
IRFD123	60	0.4	1.1	4.4	1.0	PD-9.385	
IRFD113		0.8	0.8	6.4	1.0	PD-9.328	
IRFD1Z3		3.2	0.4	3.2	1.0	PD-9.380	
IRFD020	50	0.10	2.4	19.0	1.0	PD-9.470	
IRFD022		0.12	2.2	18.0	1.0	PD-9.470	
IRFD010		0.20	1.7	14.0	1.0	PD-9.464	
IRFD012		0.30	1.4	11.0	1.0	PD-9.464	

P-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFD9220	-200	1.5	-0.6	-4.8	1.0	PD-9.439	**HD-1** Similar to MO-001AN
IRFD9210		3.0	-0.4	-1.6	1.0	PD-9.387	
IRFD9223	-150	2.4	-0.45	-3.6	1.0	–	
IRFD9213		4.5	-0.3	-1.2	1.0	PD-9.387	
IRFD9120	-100	0.6	-1.0	-8.0	1.0	PD-9.331	
IRFD9110		1.2	-0.7	-3.0	1.0	PD-9.389	
IRFD9123	-60	0.8	-0.8	-6.4	1.0	PD-9.331	
IRFD9113		1.6	-0.6	-2.5	1.0	PD-9.389	
IRFD9020	-50	0.28	-1.6	-13.0	1.0	PD-9.462	
IRFD9022		0.33	-1.4	-11.0	1.0	PD-9.462	
IRFD9010		0.50	-1.1	-8.8	1.0	PD-9.460	
IRFD9012		0.70	-0.90	-7.3	1.0	PD-9.460	

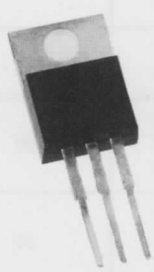
TO-220 Package

N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFBG30	1000	5.60	2.25	9.0	75	–	**TO-220AB**
IRFBF30	900	4.00	2.6	10.4	75	–	
IRFBE30	800	3.50	2.8	11.2	75	–	
IRFBC40	600	1.20	6.2	25.0	125	–	
IRFBC30		2.20	3.6	12	75	PD-9.482	
IRF840	500	0.85	8.0	32	125	PD-9.376	
IRF842		1.1	7.0	28	125	PD-9.376	
IRF830		1.5	4.5	18	75	PD-9.311	
IRF832		2.5	4.0	16	75	PD-9.311	
IRF820		3.0	2.5	10	40	PD-9.324	
IRF822		4.0	2.0	8	40	PD-9.324	

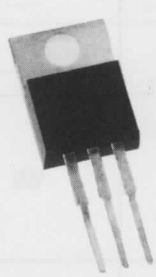
HEXFET™
TO-220 Package

N-CHANNEL

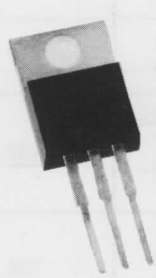
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRF841	450	0.85	8.0	32	125	PD-9.376	**TO-220AB** 
IRF843		1.1	7.0	28	125	PD-9.376	
IRF831		1.5	4.5	18	75	PD-9.311	
IRF833		2.0	4.0	16	75	PD-9.311	
IRF821		3.0	2.5	10	40	PD-9.324	
IRF823		4.0	2.0	8	40	PD-9.324	
IRF740	400	0.55	10.0	40	125	PD-9.375	
IRF742		0.80	8.0	32	125	PD-9.375	
IRF730		1.0	5.5	22	75	PD-9.308	
IRF732		1.5	4.5	18	75	PD-9.308	
IRF720		1.8	3.0	12	40	PD-9.315	
IRF722		2.5	2.5	10	40	PD-9.315	
IRF710		3.6	1.5	6	20	PD-9.327	
IRF712		5.0	1.3	5	20	PD-9.327	
IRF741	350	0.55	10.0	40	125	PD-9.375	
IRF743		0.8	8.0	32	125	PD-9.375	
IRF731		1.0	5.5	22	75	PD-9.308	
IRF733		1.5	4.5	18	75	PD-9.308	
IRF721		1.8	3.0	12	40	PD-9.315	
IRF723		2.5	2.5	10	40	PD-9.315	
IRF711		3.6	1.5	6	20	PD-9.327	
IRF713		5.0	1.3	5	20	PD-9.327	
IRF644	250	0.25	14.0	36	125	—	
IRF634		0.45	8.1	32	75	—	
IRF635		0.68	6.5	26	75	—	
IRF624		1.1	3.8	15	40	PD-9.472	
IRF625		1.5	3.3	13	40	PD-9.472	
IRF614		2.0	2.0	8.0	20	PD-9.475	
IRF615		3.0	1.6	6.4	20	PD-9.475	
IRF640	200	0.18	18.0	72	125	PD-9.374	
IRF642		0.22	16.0	64	125	PD-9.374	
IRF630		0.4	9.0	36	75	PD-9.309	
IRF632		0.6	8.0	32	75	PD-9.309	
IRF620		0.8	5.0	20	40	PD-9.317	
IRF622		1.2	4.0	16	40	PD-9.317	
IRF610		1.5	2.5	10	20	PD-9.326	
IRF612		2.4	2.0	8	20	PD-9.326	
IRF641	150	0.18	18.0	72	125	PD-9.374	
IRF643		0.22	16.0	64	125	PD-9.374	
IRF631		0.4	9.0	36	75	PD-9.309	
IRF633		0.6	8.0	32	75	PD-9.309	
IRF621		0.8	5.0	20	40	PD-9.317	
IRF623		1.2	4.0	16	40	PD-9.317	
IRF611		1.5	2.5	10	20	PD-9.326	
IRF613		2.4	2.0	8	20	PD-9.326	
IRF540	100	0.085	27.0	108	125	PD-9.373	
IRF542		0.11	24.0	96	125	PD-9.373	
IRF530		0.18	14.0	56	75	PD-9.307	
IRF532		0.25	12.0	48	75	PD-9.307	
IRF520		0.3	8.0	32	40	PD-9.313	
IRF522		0.4	7.0	28	40	PD-9.313	
IRF510		0.6	4.0	16	20	PD-9.325	
IRF512		0.8	3.5	14	20	PD-9.325	

HEXFET™
TO-220 Package

N-CHANNEL

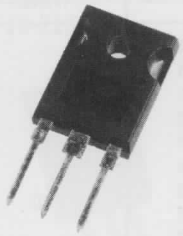
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFZ44		0.03	40.0	120	125	–	TO-220AB
IRFZ34		0.05	23.5	94	75	–	
IRF541		0.085	27.0	108	125	PD-9.373	
IRF543		0.11	24.0	96	125	PD-9.373	
IRF531		0.18	24.0	56	75	PD-9.307	
IRFZ24		0.1	15.0	60	40	–	
IRF533	60	0.25	12.0	48	75	PD-9.307	
IRF521		0.3	8.0	32	40	PD-9.313	
IRF523		0.4	7.0	28	40	PD-9.313	
IRF511		0.6	4.0	6	20	PD-9.325	
IRF513		0.8	3.5	14	20	PD-9.325	
IRFZ14		0.2	7.2	29	20	–	
IRFZ40		0.028	51.0	160	125	PD-9.435	
IRFZ42		0.035	46.0	145	125	PD-9.435	
IRFZ30		0.05	30.0	80	75	PD-9.414	
IRFZ32	50	0.07	25.0	60	75	PD-9.414	
IRFZ20		0.10	15.0	60	40	PD-9.434	
IRFZ22		0.12	14.0	56	40	PD-9.434	
IRFZ10		0.2	7.2	20	20	PD-9.440	
IRFZ12		0.3	5.9	24	20	PD-9.440	

P-CHANNEL

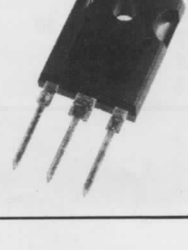
IRF9640		0.5	-11.0	-44	125	PD-9.422	TO-220AB
IRF9642		0.7	- 9.0	-36	125	PD-9.422	
IRF9630		0.8	- 6.5	-26	75	PD-9.352	
IRF9632	-200	1.2	- 5.5	-22	75	PD-9.452	
IRF9620		1.5	- 3.5	-14	40	PD-9.351	
IRF9622		2.4	- 3.0	-12	40	PD-9.351	
IRF9610		3.0	-1.75	-7	20	PD-9.350	
IRF9612		4.5	- 1.5	-6	20	PD-9.350	
IRF9641		0.5	-11.0	-44	125	PD-9.422	
IRF9643		0.7	- 9.0	-36	125	PD-9.422	
IRF9631		0.8	- 6.5	-26	75	PD-9.352	
IRF9633	-150	1.2	- 5.5	-22	75	PD-9.352	
IRF9621		1.5	- 3.5	-14	40	PD-9.351	
IRF9623		2.4	- 3.0	-12	40	PD-9.351	
IRF9611		3.0	-1.75	-7	20	PD-9.350	
IRF9613		4.5	- 1.5	-6	20	PD-9.350	
IRF9540		0.2	-19.0	-76	125	PD-9.421	
IRF9542		0.3	-15.0	-60	125	PD-9.421	
IRF9530		0.3	-12.0	-48	75	PD-9.320	
IRF9532	-100	0.4	-10.0	-40	75	PD-9.320	
IRF9520		0.6	- 6.0	-24	40	PD-9.319	
IRF9522		0.8	- 5.0	-20	40	PD-9.319	
IRF9510		1.2	- 3.0	-12	20	PD-9.390	
IRF9512		1.6	- 2.5	-10	20	PD-9.390	
IRF9541		0.2	-19.0	-76	125	PD-9.421	
IRF9543		0.3	-15.0	-60	125	PD-9.421	
IRF9531		0.3	-12.0	-48	75	PD-9.320	
IRF9533	-60	0.4	-10.0	-40	75	PD-9.320	
IRF9521		0.6	- 6.0	-24	40	PD-9.319	
IRF9523		0.8	- 5.0	-20	40	PD-9.319	
IRF9511		1.2	- 3.0	-12	20	PD-9.390	
IRF9513		1.6	- 2.5	-10	20	PD-9.390	
IRF9Z30		0.14	-18.0	-60	74	–	
IRF9Z32		0.21	-15.0	-50	74	–	
IRF9Z20	-50	0.28	- 9.7	-39	40	PD-9.461	
IRF9Z22		0.33	- 8.9	-36	40	PD-9.461	
IRF9Z10		0.50	- 4.7	-19	20	PD-9.459	
IRF9Z12		0.70	- 4.0	-16	20	PD-9.459	

HEXFET™ TO-247 Package

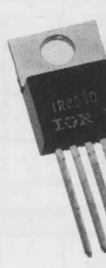
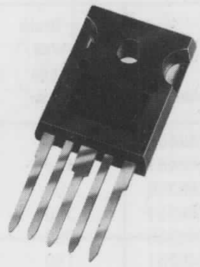
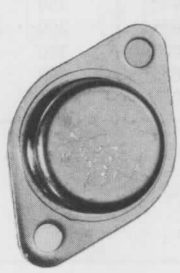
N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFPG50	1000	2.00	5.75	23	180	–	TO-247AC TO-3P 
IRFPG40		3.50	4.00	16	150	–	
IRFPF50	900	1.60	6.40	25.6	180	–	
IRFPF40		2.50	4.72	18.8	150	–	
IRFPE50	800	1.20	8.10	32.4	180	–	
IRFPE40		2.00	5.70	22.8	150	–	
IRFPC50	600	0.58	10.6	42.4	180	–	
IRFPC40		1.15	6.8	27.2	150	–	
IRFP460	500	0.27	20.0	80	250	–	
IRFP450		0.40	14.0	56	180	PD-9.458	
IRFP452		0.50	12.0	48	180	PD-9.458	
IRFP448		0.60	10.0	40	150	–	
IRFP440		0.85	8.1	32	150	PD-9.457	
IRFP442		1.10	7.1	28	150	PD-9.457	
IRFP451	450	0.40	14.0	56	180	PD-9.458	
IRFP453		0.50	12.0	48	180	PD-9.458	
IRFP441		0.85	8.1	32	150	PD-9.457	
IRFP443		1.10	7.1	28	150	PD-9.457	
IRFP360	400	0.20	25.0	100	300	–	
IRFP350		0.30	16.0	64	180	PD-9.445	
IRFP352		0.40	14.0	56	180	PD-9.445	
IRFP340		0.55	10.0	40	150	PD-9.456	
IRFP342		0.80	8.4	34	150	PD-9.456	
IRFP351	350	0.30	16.0	64	180	PD-9.445	
IRFP353		0.40	14.0	56	180	PD-9.445	
IRFP341		0.55	10.0	40	150	PD-9.456	
IRFP343		0.80	8.4	34	150	PD-9.456	
IRFP254	250	0.14	25.0	100	180	–	
IRFP244		0.25	15.0	60	150	–	
IRFP250	200	0.085	31.0	120	180	PD-9.443	
IRFP252		0.12	26.0	100	180	PD-9.443	
IRFP240		0.18	19.0	76	150	PD-9.444	
IRFP242		0.22	17.0	68	150	PD-9.444	
IRFP251	150	0.085	31.0	120	180	PD-9.443	
IRFP253		0.12	26.0	100	180	PD-9.443	
IRFP241		0.18	19.0	76	150	PD-9.444	
IRFP243		0.22	17.0	68	150	PD-9.444	
IRFP150	100	0.055	41.0	160	180	PD-9.441	
IRFP152		0.080	34.0	140	180	PD-9.441	
IRFP140		0.085	29.0	120	150	PD-9.442	
IRFP142		0.11	26.0	100	150	PD-9.442	
IRFP054	60	0.015	65.0	264	180	–	
IRFP044		0.030	43.0	172	150	–	
IRFP151		0.055	41.0	160	180	PD-9.441	
IRFP153		0.080	24.0	140	180	PD-9.441	
IRFP141		0.085	29.0	120	150	PD-9.442	
IRFP143		0.11	26.0	100	150	PD-9.442	
IRFP040	50	0.028	56	220	150	PD-9.463	
IRFP042		0.035	50	200	150	PD-9.463	

P-CHANNEL

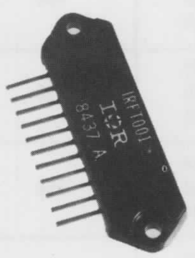
Part Numbers	V_{DS} (Volts)	$R_{DS(on)}$ (Ohms)	I_D (Amps)	I_{DM} (Amps)	P_D (Watts)	Bulletin Number	Case Style
IRFP9240	−200	0.5	−12.0	−44	125	PD-9.481	TO-247AC TO-3P 
IRFP9242		0.7	−10.0	−36	125		
IRFP9241	−150	0.5	−12.0	−44	125		
IRFP9243		0.7	−10.0	−36	125		
IRFP9140	−100	0.2	−19.0	−76	125	PD-9.480	
IRFP9142		0.3	−16.0	−60	125		
IRFP9141	−60	0.2	−19.0	−76	125		
IRFP9143		0.3	−16.0	−60	125		

HEXSense™ Current-Sensing Power MOSFETs

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRC840	500	0.85	8.0	32	125	–	5 PIN TO-220 
IRC830		1.50	4.5	18	75	PD-9.455	
IRC820		3.00	2.5	10	40	–	
IRC740	400	0.55	10.0	40	125	–	
IRC730		1.00	5.5	22	75	–	
IRC720		1.80	3.0	12	40	–	
IRC644	250	0.25	14.0	56	125	–	
IRC634		0.50	7.6	30	75	–	
IRC624		1.15	3.8	15	40	–	
IRC640	200	0.18	18.0	72	125	–	
IRC630		0.40	9.0	36	75	–	
IRC620		0.80	5.0	20	40	–	
IRC540	100	0.085	27.0	108	125	–	
IRC530		0.18	14.0	56	75	PD-9.454	
IRC520		0.30	8.0	32	40	–	
IRCZ44	60	0.03	40.0	120	125	–	
IRCZ34		0.05	23.5	94	75	–	
IRCZ24		0.10	15.0	60	40	–	
IRCZ14		0.20	7.2	29	20	–	
IRCP450	500	0.40	14.0	56	180	–	5 PIN TO-247 
IRCP440		0.85	8.1	32	150	–	
IRCP350	400	0.30	16.0	56	180	–	
IRCP340		0.55	10.0	40	150	–	
IRCP254	250	0.14	25.0	100	180	–	
IRCP244		0.25	15.0	60	150	–	
IRCP250	200	0.085	31.0	124	180	–	
IRCP240		0.18	19.0	76	150	–	
IRCP150	100	0.055	41.0	164	180	–	
IRCP140		0.085	29.0	116	150	–	
IRCP054	60	0.015	66	264	180	–	
IRCP044		0.03	43	172	150	–	
IRC450	500	0.40	14.0	56	150	–	4 PIN TO-204 
IRC440		0.85	8.0	32	125	–	
IRC430		1.5	4.5	18	75	–	
IRC420		3.0	2.5	10	40	–	
IRC350	400	0.30	16.0	64	150	–	
IRC340		0.55	10.0	40	125	–	
IRC330		1.00	5.5	22	75	–	
IRC320		1.8	3.0	12	40	–	
IRC254	250	0.14	23.0	92	150	–	
IRC244		0.25	14.0	56	125	–	
IRC234		0.45	8.1	32	75	–	
IRC224		1.10	3.8	15	40	–	
IRC250	200	0.085	31.0	120	150	–	
IRC240		0.18	18.0	72	125	–	
IRC230		0.40	9.0	36	75	–	
IRC220		0.80	5.0	20	40	–	
IRC150	100	0.055	41.0	160	150	–	
IRC140		0.085	27.0	108	125	–	
IRC130		0.180	14.0	56	75	–	
IRC120		0.30	8.0	32	40	–	

HEXFET™ Circuit Modules

Part Number	V_{DS} (Volts)	I_D Max. @ T_C = 45°C (Amps)	Max. $R_{DS(on)}$ Low Side (Ohms)	Max. $R_{DS(on)}$ High Side (Ohms)	V_R Voltage Drop Low Side (Volts)	V_R Voltage Drop High Side (Volts)	R_{thJC} (°C/W)	Circuit	Bulletin Number	Case Style
3 Ø BRIDGES for brushless DC motors										IR Y-11
IRFT001	100	4.1	0.33	0.70	2.5	−6.0	5	A	PD-5.007	
IRFT002	50	6.8	0.13	0.28	1.5	−4.5	5	A	PD-5.008	
IRFT004	50	3.4	0.24	0.50	1.0	−3.6	10	A	PD-5.010	
CPY301F	50	3.4	0.24	0.50	1.0	0.78	10	B	–	
H-BRIDGES for stepper motors, brush DC motors, servo amplifiers, power supplies										
IRFT003	50	6.8	0.13	0.28	1.5	−4.5	5	C	PD-5.009	
CPY213E	100	8.0	0.25	0.30	1.1	1.1	3	D	–	
UNIPOLAR DRIVE for stepper motors, solenoid drives										
CPY400H	100	8.4	0.25	–	2.0	1.1	3	E	PD-5.012	



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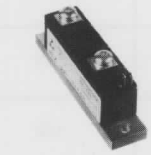
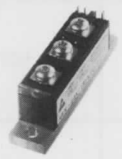
File no: E78996

HEX-pak

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Circuit	Bulletin Number	Case Style
IRFK4H450	500	0.100	44	165	500	G	PD-9.449	TO-240AA
IRFK4H451	450	0.100	44	165			PD-9.449	
IRFK4H350	400	0.075	50	190			PD-9.448	
IRFK4H351	350	0.075	50	190			PD-9.448	
IRFK4H250	200	0.021	108	380			PD-9.447	
IRFK4H251	150	0.021	108	380			PD-9.447	
IRFK4H150	100	0.014	145	500			PD-9.446	
IRFK4H151	60	0.014	145	500			PD-9.446	

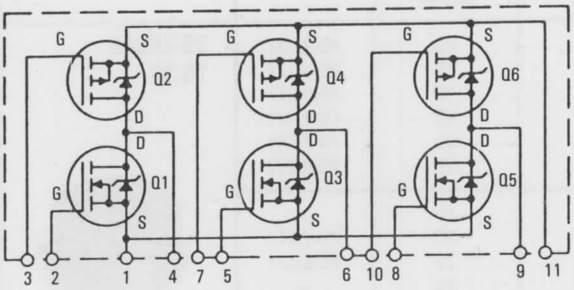


Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Circuit	Bulletin Number	Case Style
IRFK2D450	500	0.200	22	80	500	F	PD-9.453	TO-240AA
IRFK2D451	450	0.200	22	80			PD-9.453	
IRFK2D350	400	0.150	25	95			PD-9.452	
IRFK2D351	350	0.150	25	95			PD-9.452	
IRFK2D250	200	0.043	54	190			PD-9.451	
IRFK2D251	150	0.043	54	190			PD-9.451	
IRFK2D150	100	0.028	72	250			PD-9.450	
IRFK2D151	60	0.028	72	250			PD-9.450	



HEXFET™ Circuit Modules

A



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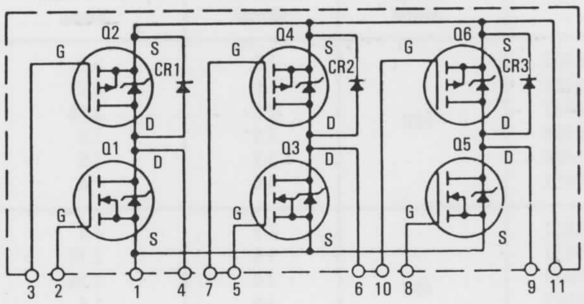

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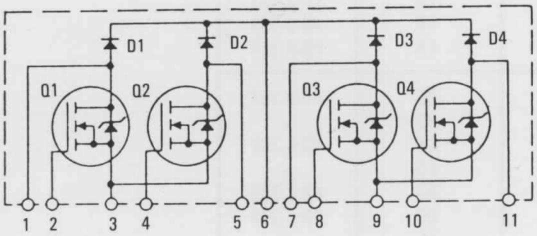

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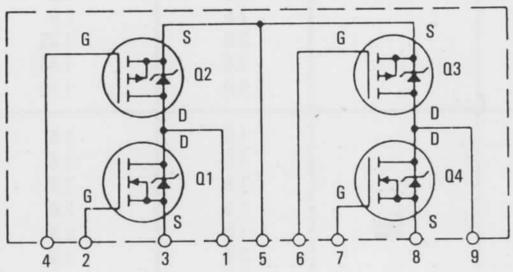

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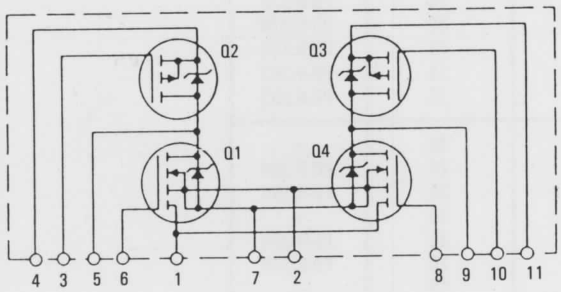

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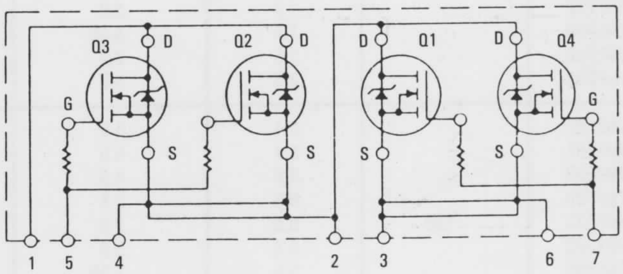

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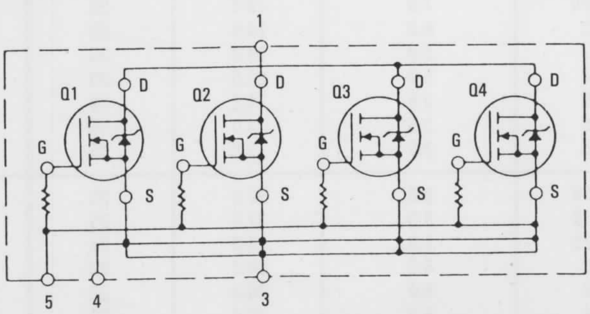


HEXFET™
Hermetic Packages
N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
2N6802		1.5	3.5	11.0	25	PD-9.433	**TO-205AF**
IRFF430		1.5	2.75	11.0	25	PD-9.377	TO-39
IRFF432		2.0	2.25	9.0	25	PD-9.377	
2N6794	500	3.0	1.5	6.5	20	PD-9.429	
IRFF420		3.0	1.6	6.5	20	PD-9.358	
IRFF422		4.0	1.4	5.5	20	PD-9.358	
2N6801		1.5	3.5	11.0	25	–	
IRFF431		1.5	2.75	11.0	25	PD-9.377	
IRFF433		2.0	2.25	9.0	25	PD-9.377	
2N6793	450	3.0	1.5	6.5	20	–	
IRFF421		3.0	1.6	6.5	20	PD-9.358	
IRFF423		4.0	1.4	5.5	20	PD-9.358	
IRFF330		1.0	3.5	14.0	25	PD-9.357	
2N6800		1.0	3.0	14.0	25	PD-9.432	
IRFF332		1.5	3.0	12.0	25	PD-9.357	
2N6792		1.8	2.0	10.0	20	PD-9.428	
IRFF320	400	1.8	2.5	10.0	20	PD-9.356	
IRFF322		2.5	2.0	8.0	20	PD-9.356	
2N6786		3.6	1.25	5.5	15	PD-9.425	
IRFF310		3.5	1.35	5.5	15	PD-9.355	
IRFF312		5.0	1.15	4.5	15	PD-9.355	
IRFF331		1.0	3.5	14.0	25	PD-9.357	
2N6799		1.0	3.0	14.0	25	–	
IRFF333		1.5	3.0	12.0	25	PD-9.357	
2N6791		1.8	2.0	10.0	20	–	
IRFF321	350	1.8	2.5	10.0	20	PD-9.356	
IRFF323		2.5	2.0	8.0	20	PD-9.356	
2N6785		3.6	1.25	5.5	15	–	
IRFF311		3.6	1.35	5.5	15	PD-9.355	
IRFF313		5.0	1.15	4.5	15	PD-9.355	
2N6798		0.4	5.5	22.0	25	PD-9.431	
IRFF230		0.4	5.5	22.0	25	PD-9.354	
IRFF232		0.6	4.5	18.0	25	PD-9.354	
2N6790		0.8	3.5	14.0	20	PD-9.427	
IRFF220	200	0.8	3.5	14.0	20	PD-9.378	
IRFF222		1.2	3.0	12.0	20	PD-9.378	
2N6784		1.5	3.25	9.0	15	PD-9.424	
IRFF210		1.5	2.2	9.0	15	PD-9.353	
IRFF212		2.4	1.8	7.5	15	PD-9.353	
2N6797		0.4	5.5	22.0	25	–	
IRFF231		0.4	5.5	22.0	25	PD-9.354	
IRFF233		0.6	4.5	18.0	25	PD-9.354	
2N6789		0.8	3.5	14.0	20	–	
IRFF221	150	0.8	3.5	14.0	20	PD-9.378	
IRFF223		1.2	3.0	12.0	20	PD-9.378	
2N6788		1.5	2.25	9.0	15	–	
IRFF211		1.5	2.2	9.0	15	PD-9.353	
IRFF213		2.4	1.8	7.5	15	PD-9.353	
2N6796		0.18	8.0	32.0	25	PD-9.430	
IRFF130		0.18	8.0	32.0	25	PD-9.341	
IRFF132		0.25	7.0	28.0	25	PD-9.341	
2N6788		0.3	6.0	24.0	20	PD-9.426	
IRFF120	100	0.3	6.0	24.0	20	PD-9.342	
IRFF122		0.4	5.0	20.0	20	PD-9.342	
2N6782		0.6	3.5	14.0	15	PD-9.423	
IRFF110		0.6	3.5	14.0	15	PD-9.343	
IRFF112		0.8	3.0	12.0	15	PD-9.343	
2N6795		0.18	8.0	32.0	25	–	
IRFF131		0.18	8.0	32.0	25	PD-9.341	
IRFF133		0.25	7.0	28.0	25	PD-9.341	
2N6787		0.3	6.0	24.0	20	–	
IRFF121	60	0.3	6.0	24.0	20	PD-9.342	
IRFF123		0.4	5.0	20.0	20	PD-9.342	
2N6781		0.6	3.5	14.0	15	–	
IRFF111		0.6	3.5	14.0	15	PD-9.343	
IRFF113		0.8	3.0	12.0	15	PD-9.343	

HEXFET™
Hermetic Packages

P-CHANNEL

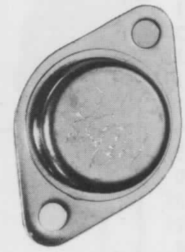
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
2N6851	-200	0.8	-4.0	-16.0	25	–	TO-205AF TO-39
IRFF9230		0.8	-4.0	-16.0	25	PD-9.384	
IRFF9232		1.2	-3.5	-14.0	25	PD-9.384	
2N6847		1.5	-2.5	-10.0	20	–	
IRFF9220		1.5	-2.5	-10.0	20	PD-9.383	
IRFF9222		2.4	-2.0	-8.0	20	PD-9.383	
IRFF9210		3.0	-1.6	-6.5	15	PD-9.382	
IRFF9212		4.5	-1.3	-5.5	15	PD-9.382	
IRFF9231	-150	0.8	-4.0	-16.0	25	PD-9.384	
2N6850		1.2	-3.5	-14.0	25	–	
IRFF9233		1.2	-3.5	-14.0	25	PD-9.384	
IRFF9221		1.5	-2.5	-10.0	20	PD-9.383	
2N6846		2.4	-2.0	-8.0	20	–	
IRFF9223		2.4	-2.0	-8.0	20	PD-9.383	
IRFF9211		3.0	-1.6	-6.5	15	PD-9.382	
IRFF9213		4.5	-1.3	-5.5	15	PD-9.382	
2N6849	-100	0.3	-6.5	-26.0	25	–	
IRFF9130		0.3	-6.5	-26.0	25	PD-9.360	
IRFF9132		0.4	-5.5	-22.0	25	PD-9.360	
2N6845		0.6	-4.0	-16.0	20	–	
IRFF9120		0.6	-4.0	-16.0	20	PD-9.359	
IRFF9122		0.8	-3.5	-14.0	20	PD-9.359	
IRFF9110		1.2	-2.6	-10.0	15	PD-9.388	
IRFF9112		1.6	-2.3	-9.0	15	PD-9.388	
IRFF9131	-60	0.3	-6.5	-26.0	25	PD-9.360	
2N6848		0.4	-5.5	-22.0	25	–	
IRFF9133		0.4	-5.5	-22.0	25	PD-9.360	
IRFF9121		0.6	-4.0	-16.0	20	PD-9.359	
2N6844		0.8	-3.5	-14.0	20	–	
IRFF9123		0.8	-3.5	-14.0	20	PD-9.359	
IRFF9111		1.2	-2.6	-10.0	15	PD-9.388	
IRFF9113		1.6	-2.3	-9.0	15	PD-9.388	

N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFJ440	500	0.85	6.0	24	70	PD-9.409	TO-213AA TO-66
IRFJ430		1.5	3.8	15	50	PD-9.408	
IRFJ420		3.0	2.5	10	40	PD-9.407	
IRFJ340	400	0.55	7.5	30	70	PD-9.406	
IRFJ330		1.0	4.5	18	50	PD-9.405	
IRFJ320		1.8	3.0	12	40	PD-9.400	
IRFJ240	200	0.18	13.0	52	70	PD-9.399	
IRFJ230		0.4	8.0	32	50	PD-9.404	
IRFJ220		0.8	5.0	20	40	PD-9.403	
IRFJ140	100	0.085	15.0	60	70	PD-9.402	
IRFJ130		0.18	12.0	40	50	PD-9.398	
IRFJ120		0.3	8.0	32	40	PD-9.401	

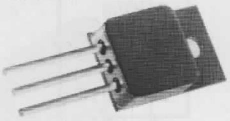
HEXFET™ Hermetic Packages

N-CHANNEL

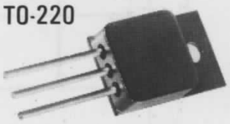
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFAG50	1000	2.0	5.25	21.0	150	–	**TO-204AA** TO-3 
IRFAG40		3.5	3.45	14.6	125		
IRFAG30		5.6	2.5	9.0	75		
IRFAF50	900	1.6	5.9	23.6	150	–	
IRFAF40		2.5	4.3	17.2	125		
IRFAF30		4.0	2.0	10.4	75		
IRFAE50	800	1.2	8.1	32.4	150	–	
IRFAE40		2.0	5.7	22.8	125		
IRFAE30		3.5	2.0	11.2	75		
IRFAC50	600	0.58	10.6	42.4	150	–	
IRFAC40		1.2	7.5	30.0	125		
IRFAC30		2.2	3.6	12.0	75		
IRF460	500	0.27	21.0	84	300	–	
IRF462		0.35	19.0	76	300	–	
2N6770		0.4	12.0	52	150	PD-9.340	
IRF450		0.4	13.0	52	150	PD-9.322	
IRF452		0.5	12.0	48	150	PD-9.322	
IRF440		0.85	8.0	32	125	PD-9.372	
IRF442		1.1	7.0	28	125	PD-9.372	
2N6762		1.5	4.5	18	75	PD-9.336	
IRF430		1.5	4.5	18	75	PD-9.310	
IRF432		2.0	4.0	16	75	PD-9.310	
IRF420		3.0	2.5	10	40	PD-9.323	
IRF422		4.0	2.0	8	40	PD-9.323	
IRF451	450	0.4	13.0	52	150	PD-9.322	
2N6769		0.5	11.0	48	150	PD-9.340	
IRF453		0.5	12.0	48	150	PD-9.322	
IRF441		0.85	8.0	32	125	PD-9.372	
IRF443		1.1	7.0	28	125	PD-9.372	
IRF431		1.5	4.5	18	75	PD-9.310	
2N6761		2.0	4.0	16	75	PD-9.336	
IRF433		2.0	4.0	16	75	PD-9.310	
IRF421		3.0	2.5	10	40	PD-9.323	
IRF423		4.0	2.0	8	40	PD-9.323	
IRF360	400	0.2	25.0	100	300	–	
2N6768		0.3	14.0	60	150	PD-9.339	
IRF350		0.3	15.0	60	150	PD-9.304	
IRF352		0.4	13.0	52	150	PD-9.304	
IRF340		0.55	10.0	40	125	PD-9.371	
IRF342		0.8	8.0	32	125	PD-9.371	
2N6760		1.0	5.5	22	75	PD-9.335	
IRF330		1.0	5.5	22	75	PD-9.302	
IRF332		1.5	4.5	18	75	PD-9.302	
IRF320		1.8	3.0	12	40	PD-9.314	
IRF322		2.5	2.5	10	40	PD-9.314	
IRF351	350	0.3	15.0	60	150	PD-9.304	
2N6767		0.4	12.0	52	150	PD-9.339	
IRF353		0.4	13.0	52	150	PD-9.304	
IRF341		0.55	10.0	40	125	PD-9.371	
IRF343		0.8	8.0	32	125	PD-9.371	
IRF331		1.0	5.5	22	75	PD-9.302	
2N6759		1.5	4.5	18	75	PD-9.335	
IRF333		1.5	4.5	18	75	PD-9.302	
IRF321		1.8	3.0	12	40	PD-9.314	
IRF323		2.5	2.5	10	40	PD-9.314	

HEXFET™
High Reliability Packages

N-CHANNEL

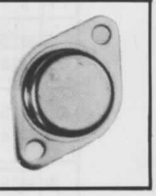
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFY440	500	0.85	5.9	24	69	EP2947	ISOLATED HERMETIC TO-220 
IRFY430		1.50	3.5	14	45		
IRFY420		3.00	2.1	8	29		
IRFY340	400	0.55	7.4	30	69	EP2947	
IRFY330		1.00	4.3	17	45		
IRFY320		1.80	2.5	7	29		
IRFY240	200	0.18	13.4	54	69	EP2947	
IRFY230		0.40	7.0	28	45		
IRFY220		0.80	4.25	17	29		
IRFY140	100	0.085	20.0	80	69	EP2947	
IRFY130		0.18	10.8	43	45		
IRFY120		0.30	6.8	27	29		

P-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFY9230	200	0.8	5.0	20	45	EP2947	ISOLATED HERMETIC TO-220 
IRFY9220		1.5	3.0	12	29		
IRFY9130	100	0.3	9.3	37	45	EP2947	
IRFY9120		0.6	5.1	26	29		

HEXFET™
High Reliability Radiation Hard HEXFETs

N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRH450	500	0.60	10.0	40	150	PD-9.479	TO-204AA (TO-3) 
IRH254	250	0.19	19.0	76	150	PD-9.477	
IRH150	100	0.055	38.0	150	150	PD-9.478	

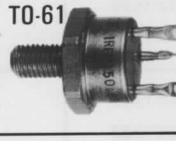
MILITARY DEVICES

MANY OF THE DEVICES IN THIS BROCHURE ARE AVAILABLE TO MIL-S-19500 AND CECC SPECIFICATION. FOR A COMPLETE LISTING OF MILITARY QUALIFIED COMPONENTS PLEASE REQUEST SELECTION GUIDE E1025 FROM YOUR LOCAL SALES OFFICE.

HEXFET™
High Reliability Packages

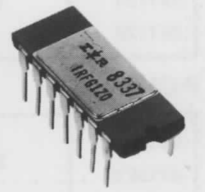
N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFH450	500	0.4	13.0	52	150	–	TO-210AC TO-61
IRFH350	400	0.3	15.0	56	150	PD-9.412	
IRFH250	200	0.09	30.0	120	150	PD-9.411	
IRFH150	100	0.06	30.0	120	150	PD-9.410	



N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFG110 IRFG120	100 100	0.8 2.6	0.95 0.45	.0 .8	1.4 1.0	PD-9.396 PD-9.395	MO-036AB
P-CHANNEL							
IRFG9110	–100	–1.4	–0.75	–3.0	1.4	PD-9.397	
N & P CHANNEL COMBINATIONS							
IRFG6110	100 –100	0.8 1.4	0.95 –0.75	4.0 –3.5	1.4 1.4	PD-9.436	
IRFG5110	100 –100	0.8 0.8	1.00 –1.00	4.0 –4.0	1.4 1.4	PD-9.437	



M-PAK

N-CHANNEL

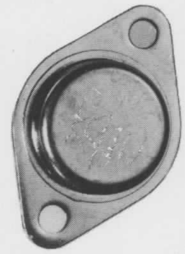
Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRFM450 IRFM440	500	0.40 0.86	11.2 7.0	40 30	125 100	PD-9.493 PD-9.492	TO-254AA
IRFM350 IRFM340	400	0.30 0.56	13.0 8.7	54 35	125 100	PD-9.491 PD-9.490	
IRFM250 IRFM240	200	0.100 0.211	25.0 15.0	80 64	125 100	PD-9.489 PD-9.488	
IRFM150 IRFM140	100	0.065 0.100	25.0 24.0	100 96	125 100	PD-9.487 PD-9.486	
IRFM050 IRFM040	50	0.03 0.04	25.0 25.0	100 100	125 100	PD-9.485 PD-9.484	

P-CHANNEL

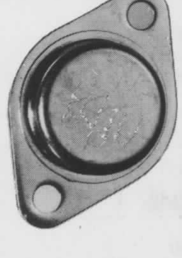
IRFM9240 IRFM9230	–200	0.51 0.81	–11.0 –6.5	–40 –26	100 75	PD-9.497 PD-9.496	TO-254AA
IRFM9140 IRFM9130	–100	0.21 0.31	–19.0 11.5	–60 –48	100 75	PD-9.495 PD-9.494	

HEXFET™
Hermetic Packages

N-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRF254	250	0.14	23.0	92	150	–	TO-204AA TO-3 
IRF244		0.25	14.0	56	125	–	
IRF234		0.45	8.1	32	75	–	
IRF235		0.75	6.2	25	75	–	
IRF224		1.1	3.8	15	40	PD-9.473	
IRF225		1.5	3.3	13	40	PD-9.473	
2N6766	200	0.085	30.0	120	150	PD-9.388	
IRF250		0.085	30.0	120	150	PD-9.321	
IRF252		0.12	25.0	100	150	PD-9.321	
IRF240		0.18	18.0	72	125	PD-9.370	
IRF242		0.22	16.0	64	125	PD-9.370	
2N6758		0.4	9.0	36	75	PD-9.334	
IRF230		0.4	9.0	36	75	PD-9.306	
IRF232		0.6	8.0	32	75	PD-9.306	
IRF220		0.8	5.0	20	40	PD-9.306	
IRF222		1.2	4.0	16	40	PD-9.316	
IRF251	150	0.085	30.0	120	150	PD-9.321	
2N6765		0.12	25.0	100	150	PD-9.338	
IRF253		0.12	25.0	100	150	PD-9.321	
IRF241		0.18	18.0	72	125	PD-9.370	
IRF243		0.22	16.0	64	125	PD-9.370	
IRF231		0.4	9.0	36	75	PD-9.306	
2N6757		0.6	8.0	32	75	PD-9.334	
IRF233		0.6	8.0	32	75	PD-9.306	
IRF221		0.8	5.0	20	40	PD-9.316	
IRF223		1.2	4.0	16	40	PD-9.316	
2N6764	100	0.055	38.0	160	150	PD-9.337	
IRF150		0.055	40.0	160	150	PD-9.305	
IRF152		0.08	33.0	132	150	PD-9.305	
IRF140		0.085	27.0	108	125	PD-9.369	
IRF142		0.11	24.0	96	125	PD-9.369	
2N6756		0.18	14.0	56	75	PD-9.333	
IRF130		0.18	14.0	56	75	PD-9.303	
IRF132		0.25	12.0	48	75	PD-9.303	
IRF120		0.3	8.0	32	40	PD-9.312	
IRF122		0.4	7.0	28	40	PD-9.312	
IRF054	60	0.015	60.0	240	150	–	
IRF044		0.03	40.0	120	125	–	
IRF034		0.05	23.5	94	75	–	
IRF151		0.055	40.0	160	150	PD-9.305	
2N6763		0.08	31.0	132	150	PD-9.337	
IRF153		0.08	33.0	132	150	PD-9.305	
IRF141		0.085	27.0	108	125	PD-9.369	
IRF024		0.1	12.0	48	40	–	
IRF143		0.11	24.0	96	125	PD-9.369	
IRF131		0.18	14.0	56	75	PD-9.303	
2N6755		0.25	12.0	48	75	PD-9.333	
IRF133		0.25	12.0	48	75	PD-9.303	
IRF121		0.3	8.0	32	40	PD-9.312	
IRF123		0.4	7.0	28	40	PD-9.312	

P-CHANNEL

Part Numbers	V_{DS} Drain Source Voltage (Volts)	$R_{DS(on)}$ On-State Resistance (Ohms)	I_D Continuous Drain Current 25°C Case (Amps)	I_{DM} Pulse Drain Current (Amps)	P_D Max. Power Dissipation (Watts)	Bulletin Number	Case Style
IRF9240	-200	0.5	-11.0	-44	125	PD-9.420	TO-204AA TO-3 
IRF9242		0.7	-9.0	-36	125	PD-9.420	
2N6806		0.8	-6.5	-26	75	–	
IRF9230		0.8	-6.5	-26	75	PD-9.349	
IRF9232		1.2	-5.5	-22	75	PD-9.349	
IRF9241	-150	0.5	-11.0	-44	125	PD-9.420	
IRF9243		0.7	-9.0	-36	125	PD-9.420	
IRF9231		0.8	-6.5	-26	75	PD-9.349	
IRF9233		1.2	-5.5	-22	75	PD-9.349	
IRF9140	-100	0.2	-19.0	-76	125	PD-9.419	
IRF9142		0.3	-15.0	-60	125	PD-9.419	
2N6804		0.3	-12.0	-48	75	–	
IRF9130		0.3	-12.0	-48	75	PD-9.318	
IRF9132		0.4	-10.0	-40	75	PD-9.318	
IRF9141	-60	0.2	-19.0	-76	125	PD-9.419	
IRF9143		0.3	-15.0	-60	125	PD-9.419	
IRF9131		0.3	-12.0	-48	75	PD-9.318	
IRF9133		0.4	-10.0	-40	75	PD-9.318	

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	Via Arno 1, 40139 **BOLOGNA.** Tel: (051) 49 33 07.
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Sales Offices, Agents and Distributors in Major Cities throughout the World.

Preliminary Data Sheet No. PD-6.011

INTERNATIONAL RECTIFIER IOR

HIGH VOLTAGE BRIDGE DRIVER

IR2110

14-PIN MOLDED DIP PACKAGE

1 20"000

General Description

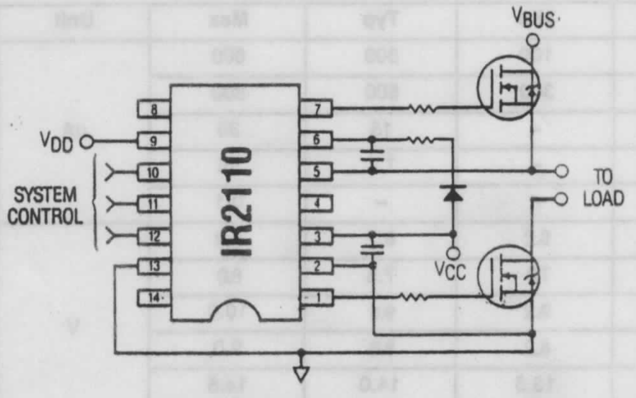
The IR2110 is a monolithic high voltage and high speed dual driver with independent floating rail high side and fixed rail low side referenced output channels. The device inputs are compatible with standard CMOS outputs or with LSTTL outputs using pullup resistors. Unique HVIC technology and circuit design enable high speed and low dissipation translation of the logic level inputs into corresponding low impedance output swings with respect to the floating and the fixed supply rail. The floating channel can be configured to drive an n-channel power MOSFET or IGBT whose source voltage is up to 500 volts from the IR2110 common pin.

The IR2110 is typically used to drive high voltage switching power MOSFETs or IGBTs in half-bridge, dual-forward or other topologies. Applications include switching power supplies, motor controls, inverters, choppers, audio amplifiers and high energy pulse circuits.

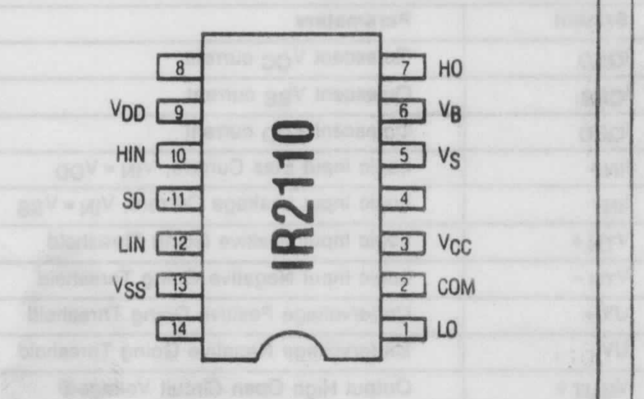
Features

- 500V rated floating supply offset voltage
- 10V/ns floating supply dv/dt immunity
- 2A peak output current capability per channel
- 25ns switching time with 1000pf load
- 100ns propagation delay time
- 1 to 5 MHz maximum repetitive rate depending on power dissipation
- CMOS Schmitt-triggered inputs with hysteresis
- 10 to 20V output drive operating voltage range
- 15mW total quiescent power dissipation with 15V supply
- Under-voltage lockout

Typical Connection



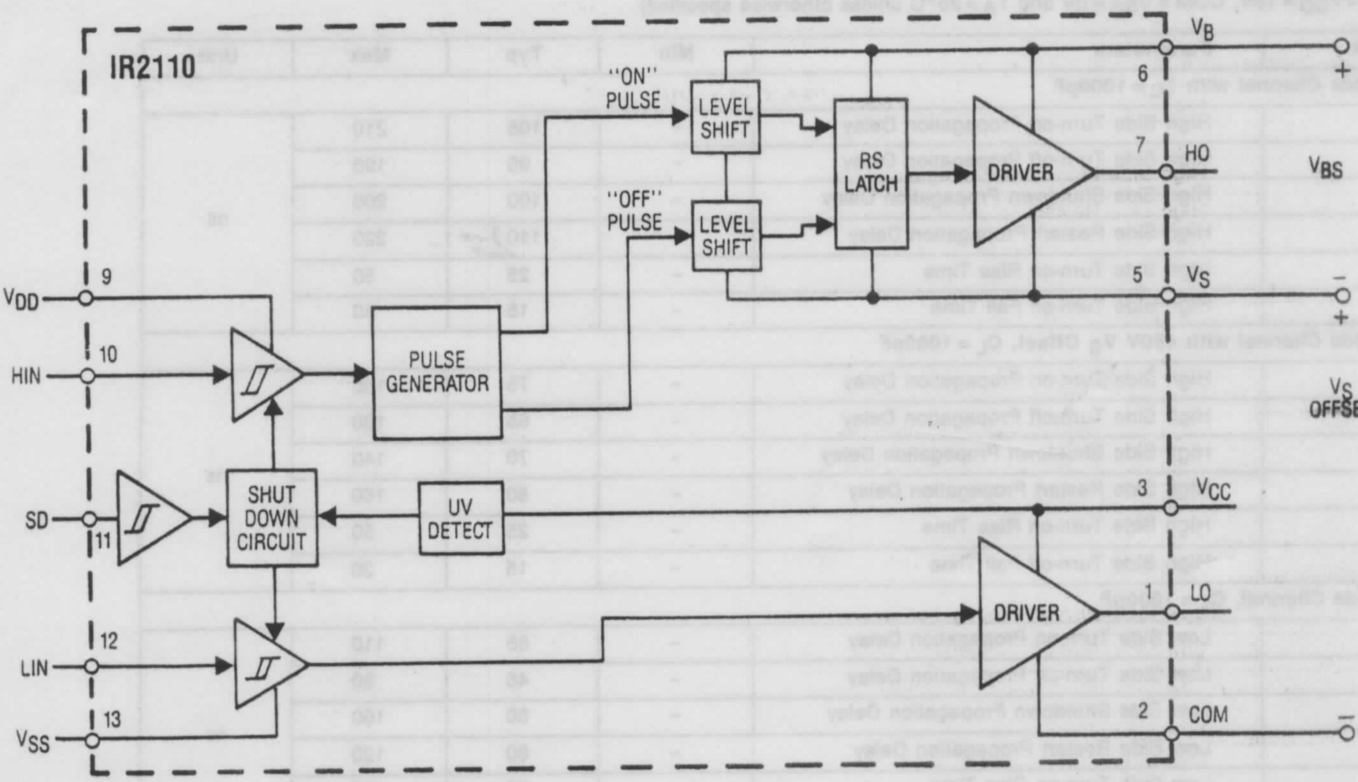
Pinout Assignment



For mechanical specifications see back page

LM 3524/25 (?)
SG

Functional Block Diagram



V_R, V_S, V_{CC}, V_{LO}, and V_{SS} are absolute voltages referenced to COM.
V_{BS} and V_{HO} are differential voltages referenced to V_S.
V_{DD} and V_{IN}'s (HIN, LIN and SD) are diff. voltages referenced to V_{SS}.

NOTES:

① Absolute DC ratings indicate sustained limits beyond which damage to the device may occur. For proper operation the device should be used within the recommended DC operating conditions.

② The Floating Supply Startup Transient is the maximum allowable rate of change for the differential V_{BS} voltage during the time interval when the floating supply is being charged from 0V to its operating value. Exceeding the limit may induce false triggering for the high side output.

③ The Offset Supply Operating Transient is the maximum allowable rate of change for the absolute V_S voltage during normal operating condition with V_{BS} fully charged to its operating value and the floating supply is swinging through its offset range. Exceeding the limit may induce false triggering for the high side output. The rating is a function of the floating supply differential and offset voltages and the switching characteristics of the test circuit. In general the rating goes up with higher offset voltage. The maximum rating specified in this section is measured at an operating offset voltage of 250V and differential voltage of 15V.

④ The input characteristics are applicable to all three Logic Input Pins: HIN, LIN and SD. The Output characteristics are applicable to the two Output Pins: HO and LO.

⑤ The Output High Open Circuit Voltage is the voltage level of the output pin with $I_{OUT}=0$ and $V_{IN}=$ "1". The Output Low Open Circuit Voltage is the voltage level of the output pin with $I_{OUT}=0$ and $V_{IN}=$ "0". The two voltage levels are the output steady state "ON" and "OFF" voltages while driving capacitive load such as the gate of power MOSFET or IGBT.

⑥ The Output High Short Circuit Current is the current sourcing from the output pin to a short circuit load with $V_{OUT}=V-$ and $V_{IN}=$ "1". The Output Low Short Circuit Current is the current sinking from a short circuit load into the output pin with $V_{OUT}=V+$ and $V_{IN}=$ "0". The two current levels are the peak current sourcing and sinking capabilities of the output driver stage. The parameters are obtained using pulse test with pulse width <100us and duty cycle <1%.

Input/Output Truth Table

HIN	LIN	SD	HO	LO
0	0	0	0	0
0	1	0	0	1
1	0	0	1	0
1	1	0	1	1
X	X	1	0	0

Typical Performance Characteristics

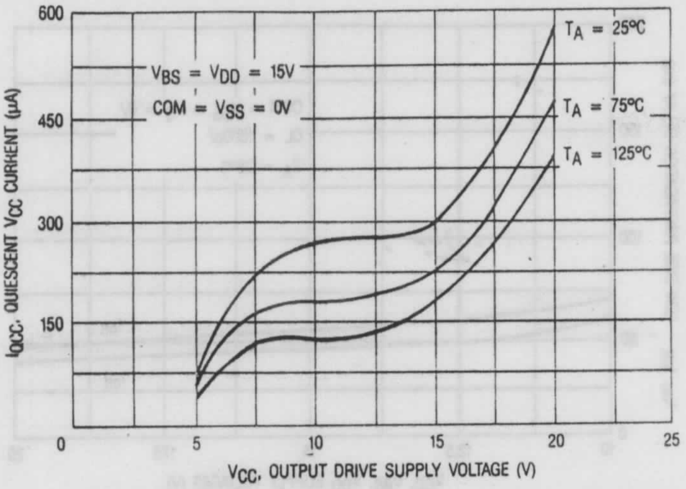


Fig. 1 — Quiescent Current Vs. V_{CC} Supply Voltage

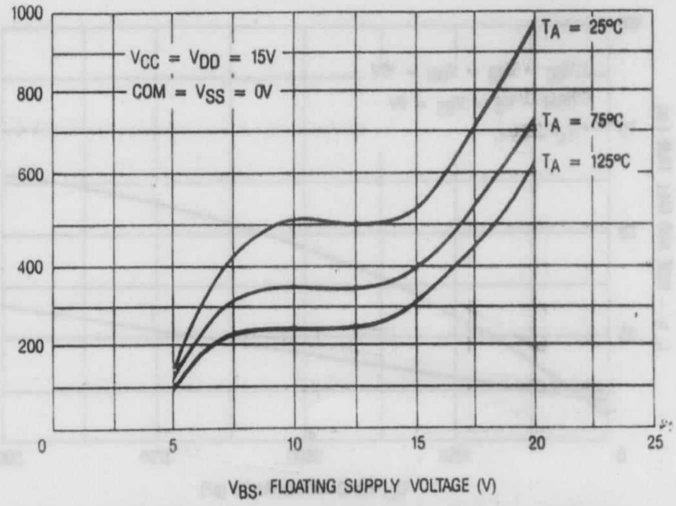


Fig. 2 — Quiescent Current Vs. V_{BS} Supply Voltage

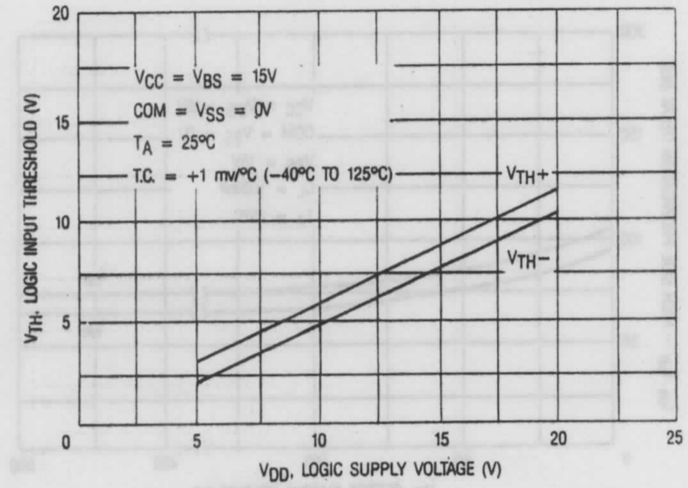


Fig. 3 — Logic Input Threshold Vs. V_{DD} Supply Voltage

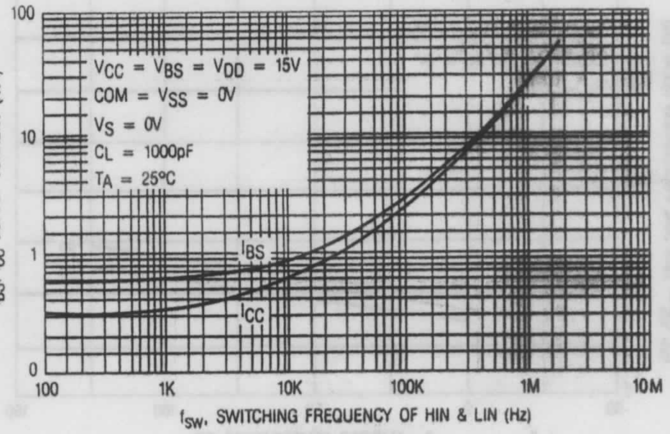


Fig. 4 — Supply Current Vs. Switching Frequency (0V V_S Offset)

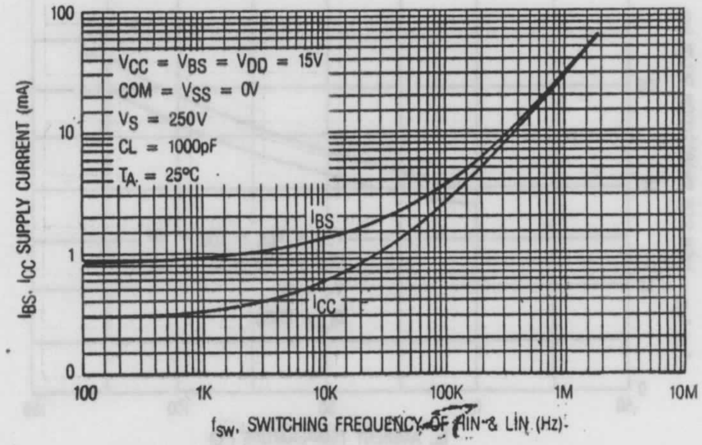


Fig. 5 — Supply Current Vs. Switching Frequency (250V V_S Offset)

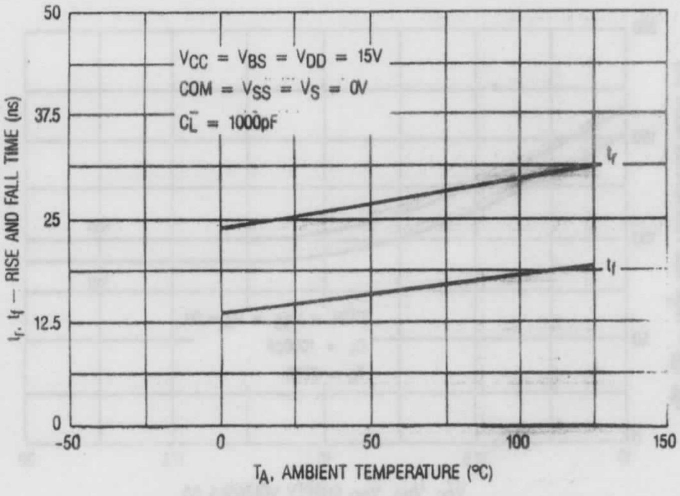


Fig. 6 — Rise And Fall Time Vs. Temperature

FUNCTIONAL DESCRIPTION

The IR2110 is a monolithic high voltage and high speed dual power MOSFET driver. Refer to the Functional Block Diagram for the internal partitioning of the various circuit blocks. The driver translates logic input signals into corresponding in-phase low impedance outputs. One drive channel output (LO) is referenced to a fixed rail (V_{CC}) and the other channel output (HO) is referenced to a floating rail (V_{BS}) with offset capability up to 500V.

The logic section provides the control pulses for the two output channels as indicated by the Input/Output Truth Table. In the case when V_{CC} is below the undervoltage trip point, the UV detect block will send a shutdown signal to both channels. The logic inputs use Schmitt trigger with a hysteretic band of 0.8 X V_{DD} to provide high noise immunity and can accept inputs with slow rise time. The logic section is referenced to its own logic supply allowing use of a lower supply voltage than the output drive supply voltage and also avoiding noise coupling from the switching action of the output drivers.

Both channels use identical low cross-conduction totem pole output drivers. The output drivers are two n-channel MOSFETs with peak current capability up to 2 amperes. One output driver is connected as a source follower and the other is connected in a common source configuration. The rise time is slower than the fall time when driving capacitive loads due to the inherent totem pole arrangement.

For the high side channel, 30ns ON and OFF pulses are triggered by the respective rising and falling edges of the HIN signal. These pulses are used to drive separate high voltage DMOS level translators that set or reset a RS latch that operates off the floating rail. The inputs of the RS latch are pulled high by active current sources, placing the output in the normally OFF condition. The latch is set or reset by current pulses from the level translators that overcome the active pull-up current. Since the high voltage DMOS level translators are turned ON for only 30ns for each Set and Reset event, power dissipation is minimized. However, when the level translators are in the OFF state, fast dv/dt transients on the V_S node can couple spurious pull-down pulses to the latch inputs. If the spurious pull-down pulses exceed the active pull-up current, the high side output turns ON and a false trigger occurs on the output.

APPLICATION GUIDELINES

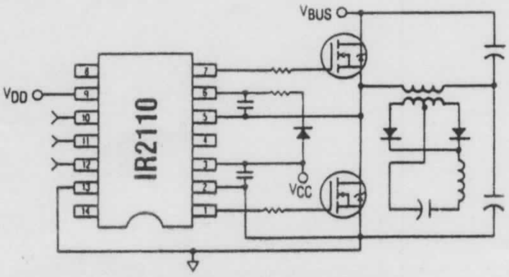
The IR2110 is typically used to drive two high voltage n-channel power MOSFETs or IGBTs configured in a half-bridge, dual-forward, or other topology. The fixed rail referenced output is used to drive a low side connected power MOSFET or IGBT. The floating output channel is used to drive an n-channel power MOSFET or IGBT in the high side configuration that requires an over-rail gate drive. Refer to the section on Typical Application for the various circuit topologies where the IR2110 is applicable.

Typically, the floating supply is derived from the fixed supply using a bootstrap technique as shown in the section on Typical Connections. The charging diode must have a voltage withstand capability higher than the peak V_{BUS} voltage. In order to limit the charging current of the reservoir capacitor, a series resistor is inserted in the charging path. This limits the DV_{BS}/dt. The values of the capacitor and the series resistor depend on the switching frequency, duty cycle, gate charge requirement of the power MOSFET and the startup transient of the bootstrapped floating supply. A 0.047μF capacitor and 10 ohm resistor are usually suitable for applications above 10KHz, depending on duty cycle.

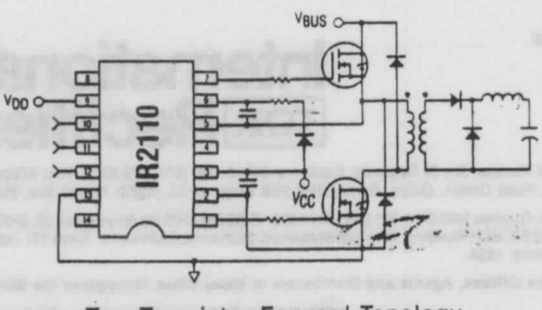
The outputs of the IR2110 are designed to deliver gate drives for fast switching speeds — even for high current power MOSFET with relatively high gate charge requirement. For smaller power MOSFETs, a series gate resistor for each output is recommended to limit power device switching speeds. The value of the gate resistor depends on EMI requirements, switching losses and the maximum allowable dv/dt of the V_S node.

Supply bypass capacitors between V_{CC} and COM, and between V_{DD} and V_S are required to supply the transient current needed for switching the capacitive load. These capacitors together with the reservoir capacitor across V_B and V_S must be connected close to the actual device. A 0.47μF ceramic disk capacitor in parallel with a 4.7μF tantalum capacitor is recommended for the V_{CC} bypass. A 0.1μF ceramic disk capacitor is usually adequate for the logic supply bypass.

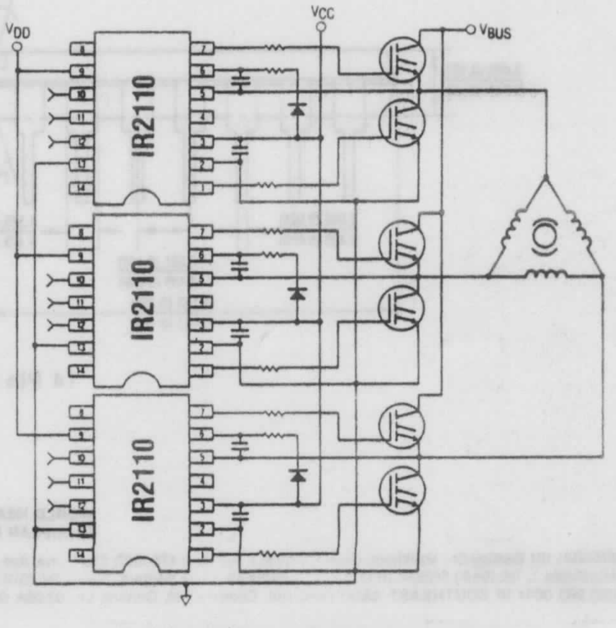
Typical Applications



Half-Bridge Power Supply



Two Transistor Forward Topology



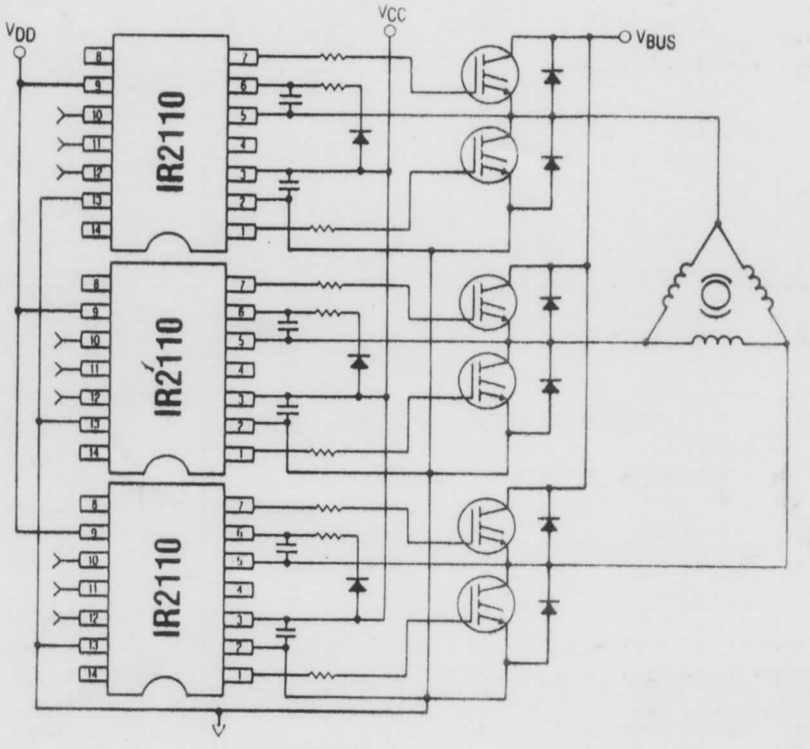
3-Phase Bridge Motor Drive

ERRATA SHEET FOR THE IR2110 BRIDGE DRIVER

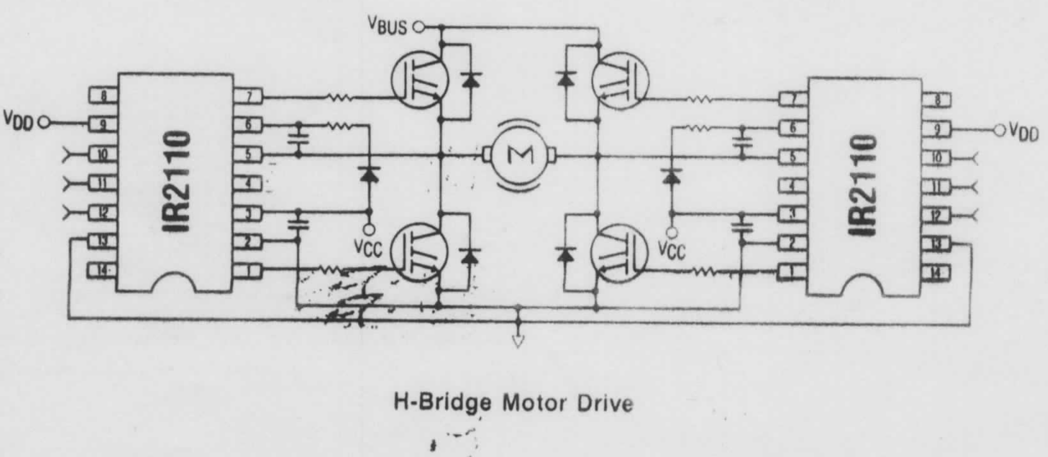
CORRECTION

Please note that in the Application Section of the IR2110 Data Sheet, free wheel diodes should be shown across all IGBT's. This applies to the 3-Phase Bridge Motor Drive and H-Bridge Motor Drive Schematics.

The corrected schematics are shown below:



3-Phase Bridge Motor Drive



H-Bridge Motor Drive

CONSIDERATIONS
INDUCTANCE
LANE
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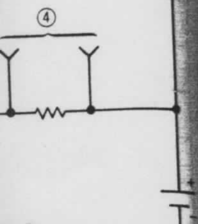
RANSFORMER



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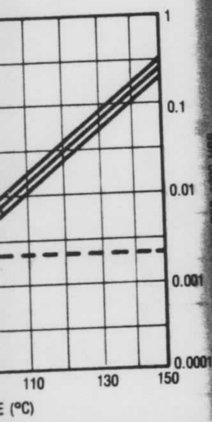


perature Reverse Bias
ilure Rate

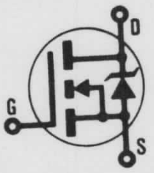
INTERNATIONAL RECTIFIER IOR

REPETITIVE AVALANCHE AND dv/dt RATED*

HEXFET® TRANSISTORS

IRF740
IRF741
IRF742
IRF743

TO-220



N-CHANNEL

400 Volt, 0.55 Ohm HEXFET TO-220AB Plastic Package

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of this latest "State of the Art" design achieves: very low on-state resistance combined with high transconductance; superior reverse energy and diode recovery dv/dt capability.

The HEXFET transistors also feature all of the well established advantages of MOSFETs such as voltage control, very fast switching, ease of paralleling and temperature stability of the electrical parameters.

They are well suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers and high energy pulse circuits.

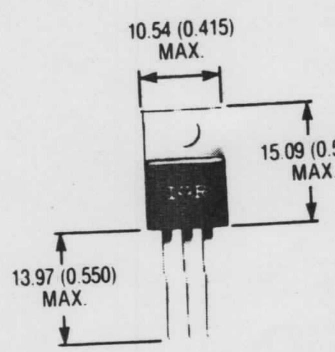
Product Summary

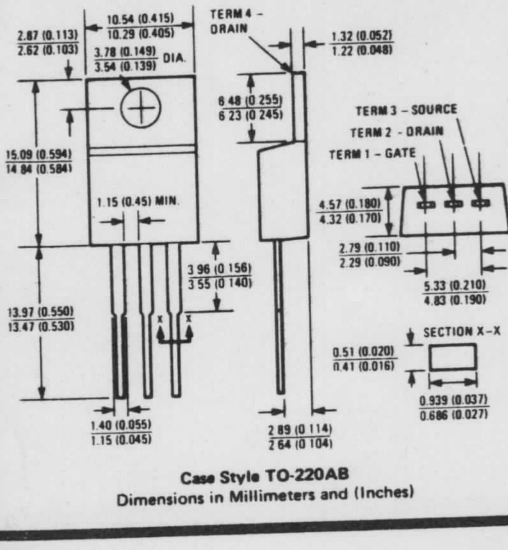
Part Number	BV_{DSS}	$R_{DS(on)}$	I_D
IRF740	400V	0.55Ω	10A
IRF741	350V	0.55Ω	10A
IRF742	400V	0.80Ω	8.3A
IRF743	350V	0.80Ω	8.3A

FEATURES:

- Repetitive Avalanche Ratings
- Dynamic dv/dt Rating
- Simple Drive Requirements
- Ease of Paralleling

CASE STYLE AND DIMENSIONS





Case Style TO-220AB
Dimensions in Millimeters and (Inches)

*This data sheet applies to product with batch codes that begin with a digit, ie. 2A3B

Absolute Maximum Ratings

Parameter		IRF740, IRF741	IRF742, IRF743	Units
I_D @ T_C = 25°C	Continuous Drain Current	10	8.3	A
I_D @ T_C = 100°C	Continuous Drain Current	6.3	5.2	A
I_{DM}	Pulsed Drain Current ①	40	33	A
P_D @ T_C = 25°C	Max. Power Dissipation	125		W
	Linear Derating Factor	1.0		W/K ⑤
V_{GS}	Gate-to-Source Voltage	±20		V
E_{AS}	Single Pulse Avalanche Energy ②	520 (See Fig. 14)		mJ
I_{AR}	Avalanche Current ① (Repetitive or Non-Repetitive)	10 (See E_{AR})		A
E_{AR}	Repetitive Avalanche Energy ①	13 (See I_{AR})		mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.0 (See Fig. 17)		V/ns
T_J T_{STG}	Operating Junction Storage Temperature Range	−55 to 150		°C
	Lead Temperature	300 (0.063 in. (1.6mm) from case for 10s)		°C

Electrical Characteristics @ T_J = 25°C (Unless Otherwise Specified)

Parameter		Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain-to-Source Breakdown Voltage	IRF740 IRF742	400	–	–	V	V_{GS} = 0V, I_D = 250 μA
		IRF741 IRF743	350				
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance ④	IRF740 IRF741	–	0.42	0.55	Ω	V_{GS} = 10V, I_D = 5.2A
		IRF742 IRF743	–	0.55	0.80		
$I_{D(on)}$	On-State Drain Current ④	IRF740 IRF741	10	–	–	A	$V_{DS} > I_{D(on)} \times R_{DS(on)}$ Max. V_{GS} = 10V
		IRF742 IRF743	8.3				
$V_{GS(th)}$	Gate Threshold Voltage	ALL	2.0	–	4.0	V	$V_{DS} = V_{GS}$, I_D = 250μA
g_{fs}	Forward Transconductance ④	ALL	5.8	8.7	–	S (℧)	$V_{DS} \geq$ 50V, I_{DS} = 5.2A
I_{DSS}	Zero Gate Voltage Drain Current	ALL	–	–	250	μA	V_{DS} = Max. Rating, V_{GS} = 0V
			–	–	1000		V_{DS} = 0.8 x Max. Rating V_{GS} = 0V, T_J = 125°C
I_{GSS}	Gate-to-Source Leakage Forward	ALL	–	–	500	nA	V_{GS} = 20V
I_{GSS}	Gate-to-Source Leakage Reverse	ALL	–	–	−500	nA	V_{GS} = −20V
Q_g	Total Gate Charge	ALL	–	42	63	nC	V_{GS} = 10V, I_D = 10A
Q_{gs}	Gate-to-Source Charge	ALL	–	6.0	9.0	nC	V_{DS} = 0.8 x Max. Rating See Fig. 16
Q_{gd}	Gate-to-Drain ("Miller") Charge		–	21	32	nC	(Independent of operating temperature)
$t_{d(on)}$	Turn-On Delay Time	ALL	–	14	21	ns	V_{DD} = 200V, I_D ≈ 10A, R_G = 9.1Ω
t_r	Rise Time	ALL	–	27	41	ns	R_D = 20Ω
$t_{d(off)}$	Turn-Off Delay Time	ALL	–	50	75	ns	See Fig. 15
t_f	Fall Time	ALL	–	24	36	ns	(Independent of operating temperature)
L_D	Internal Drain Inductance	ALL	–	4.5	–	nH	Measured from the drain lead, 6mm (0.25 in.) from package to center of die. Modified MOSFET symbol showing the internal inductances.
L_S	Internal Source Inductance	ALL	–	7.5	–	nH	Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.
C_{iss}	Input Capacitance	ALL	–	1300	–	pF	V_{GS} = 0V, V_{DS} = 25V
C_{oss}	Output Capacitance	ALL	–	210	–	pF	f = 1.0 MHz
C_{rss}	Reverse Transfer Capacitance	ALL	–	37	–	pF	See Fig. 10

TO-220

Source-Drain Diode Ratings and Characteristics

Parameter		Type	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	ALL	–	–	10	A	Modified MOSFET symbol showing the integral Reverse p-n junction rectifier.
I_{SM}	Pulsed Source Current (Body Diode) ①	ALL	–	–	40	A	
V_{SD}	Diode Forward Voltage ④	ALL	–	–	2.0	V	T_J = 25°C, I_S = 10A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	ALL	170	370	790	ns	T_J = 25°C, I_F = 10A, di/dt = 100 A/μs
Q_{RR}	Reverse Recovery Charge	ALL	1.6	3.8	8.2	μC	
t_{on}	Forward Turn-On Time	ALL	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S + L_D$.				

Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	–	–	1.0	K/W ⑤	
R_{thCS}	Case-to-Sink	ALL	–	0.50	–	K/W ⑤	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	ALL	–	–	80	K/W ⑤	Typical socket mount

Typical SPICE Computer Model Parameters (For more Information See Application Note AN-975)

Device	Level, SPICE MOSFET Model	W (m), Channel Width	L (μm), Channel Length	Theta (1/V), Mobility Modulation	UO (CM^2/V-S), Surface Mobility	VTO (V), Threshold Voltage	R1 (Ω), Drain Resistance	R2 (Ω), Source Resistance	RG (Ω), Gate Resistance
ALL	3	0.978	1.2	0.15	450	3.80	0.40	0.02	0.5

CGSO (pf), Gate-Source Capacitance	CGD (F) Gate-Drain Capacitance	E1 (V), Voltage Dependent Voltage Source	LD (nH), Drain Inductance	LS (nH), Source Inductance	LG (nH), Gate Inductance	IS (A), Diode Saturation Current	RS (Ω), Diode Bulk Resistance
820	C8	2 + 0.995 VDG	4.5	7.5	7.5	1.2×10^{-12}	0.011

$C8 = 3000\ pf + 7 \times 10^{-22} (V_{GE})^{48}$

① Repetitive Rating; Pulse width limited by maximum junction temperature (see figure 5) Refer to current HEXFET reliability report

② @ V_{DD} = 50V, Starting T_J = 25°C, L = 9.1 mH, R_G = 25Ω, Peak I_L = 10A.

③ $I_{SD} \leq$ 10A, di/dt ≤ 120A/μs, $V_{DD} \leq BV_{DSS}$, $T_J \leq$ 150°C Suggested R_G = 9.1Ω

④ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%

⑤ K/W = °C/W W/K = W/°C

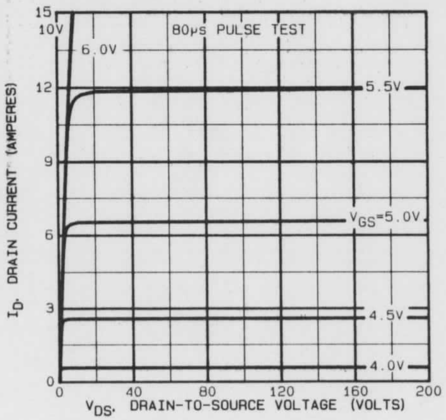


Fig. 1 — Typical Output Characteristics

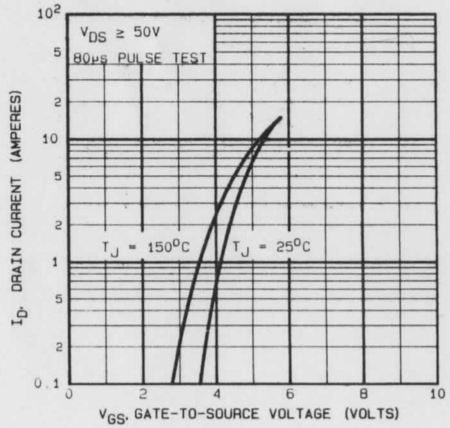


Fig. 2 — Typical Transfer Characteristics

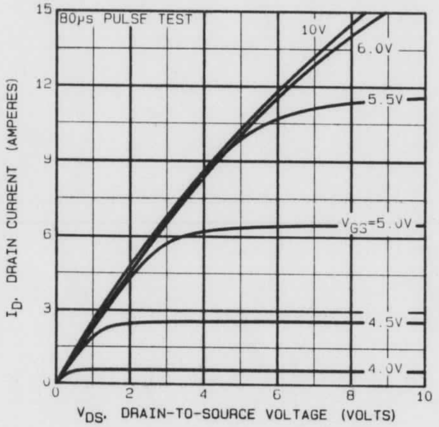


Fig. 3 — Typical Saturation Characteristics

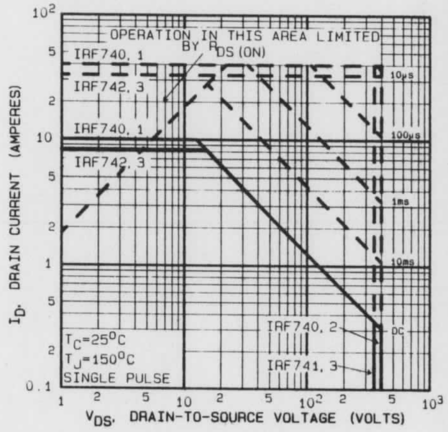


Fig. 4 — Maximum Safe Operating Area

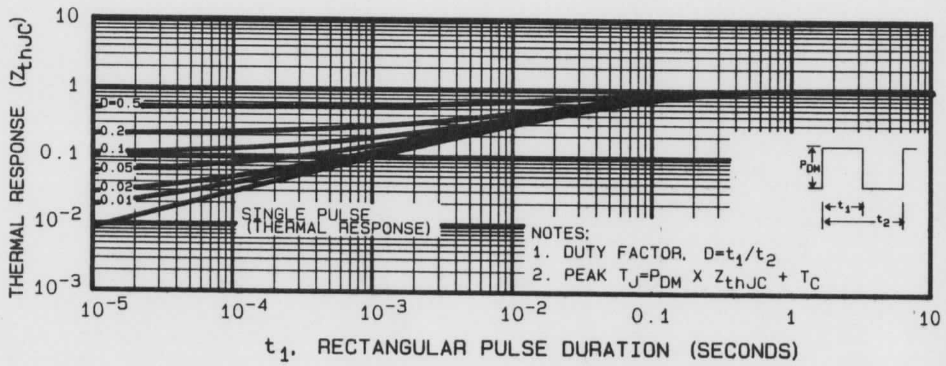


Fig. 5 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

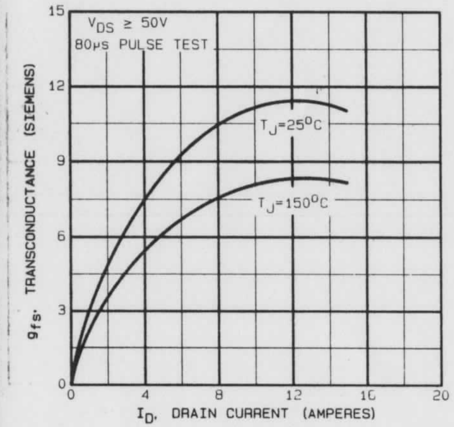


Fig. 6 — Typical Transconductance Vs. Drain Current

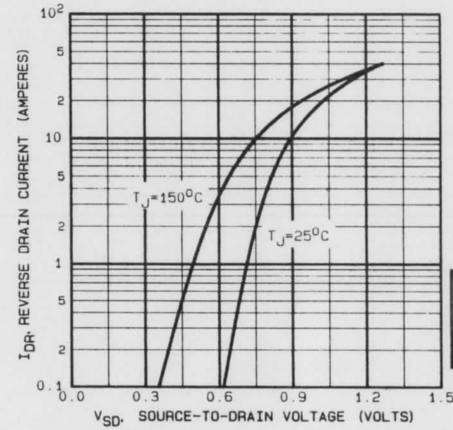


Fig. 7 — Typical Source-Drain Diode Forward Voltage

TO-220

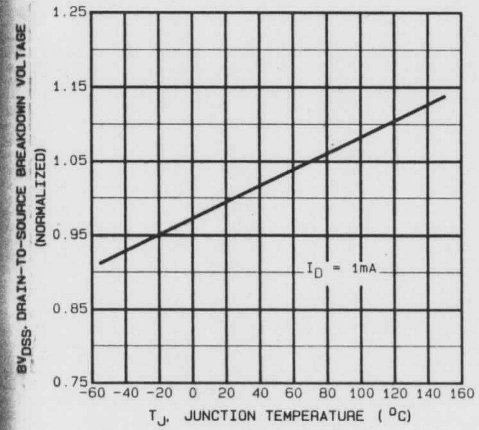


Fig. 8 — Breakdown Voltage Vs. Temperature

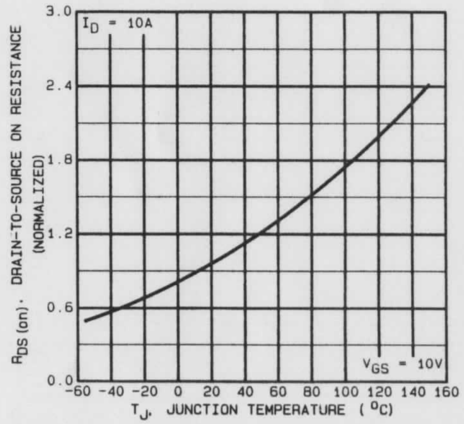


Fig 9 — Normalized On-Resistance Vs. Temperature

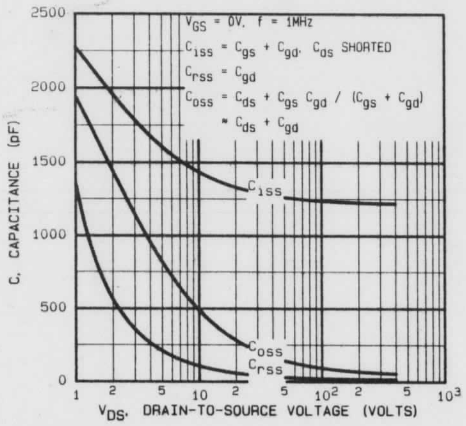


Fig. 10 — Typical Capacitance Vs. Drain-to-Source Voltage

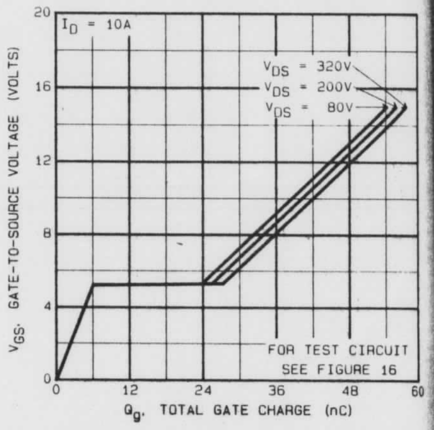


Fig. 11 — Typical Gate Charge Vs. Gate-to-Source Voltage

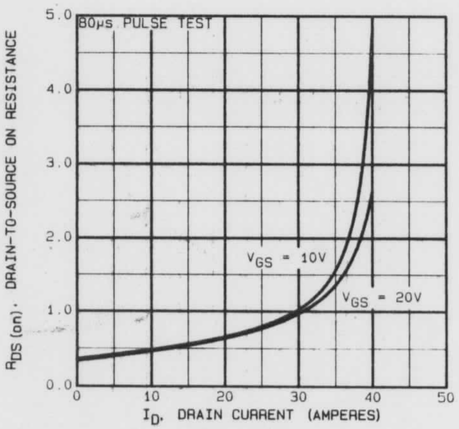


Fig. 12 — Typical On-Resistance Vs. Drain Current

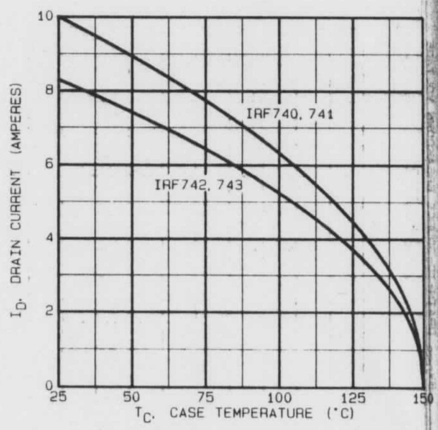


Fig. 13 — Maximum Drain Current Vs. Case Temperature

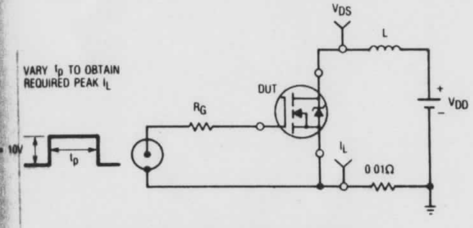


Fig. 14a — Unclamped Inductive Test Circuit

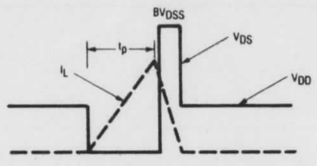


Fig. 14b — Unclamped Inductive Waveforms

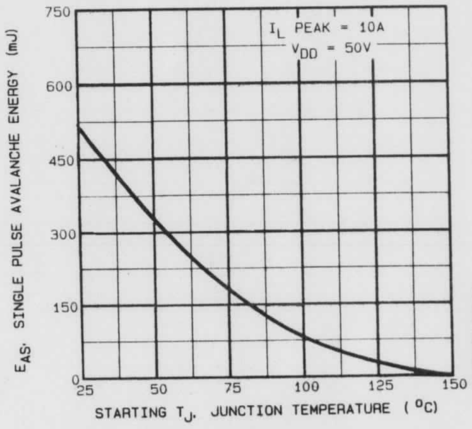


Fig. 14c — Maximum Avalanche Energy Vs. Starting Junction Temperature

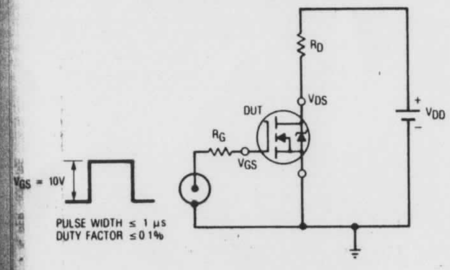


Fig. 15a — Switching Time Test Circuit

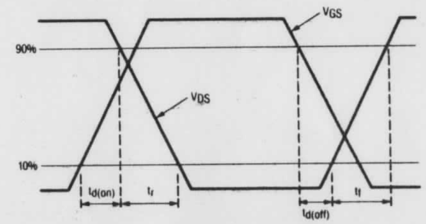


Fig. 15b — Switching Time Waveforms

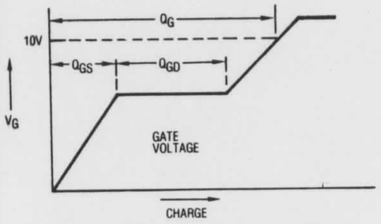


Fig. 16a — Basic Gate Charge Waveform

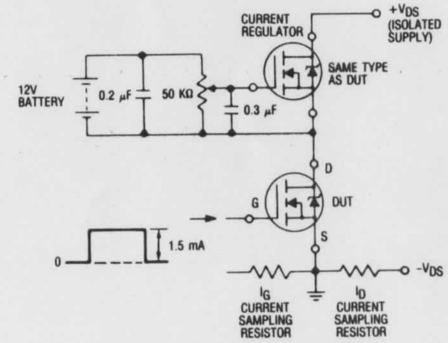


Fig. 16b — Gate Charge Test Circuit

TO-220

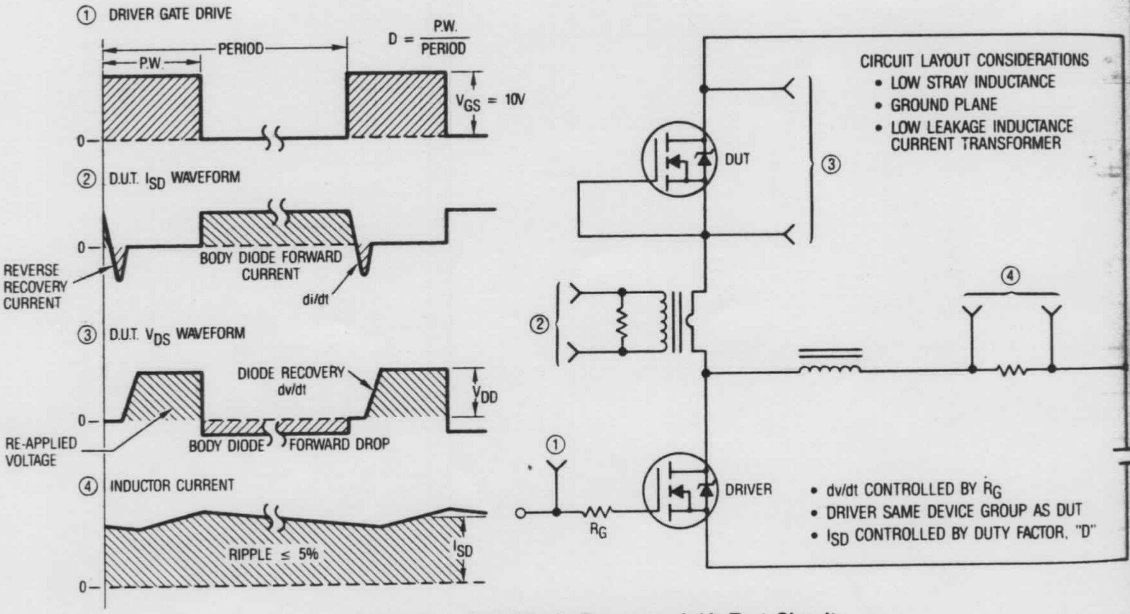


Fig. 17 — Peak Diode Recovery dv/dt Test Circuit

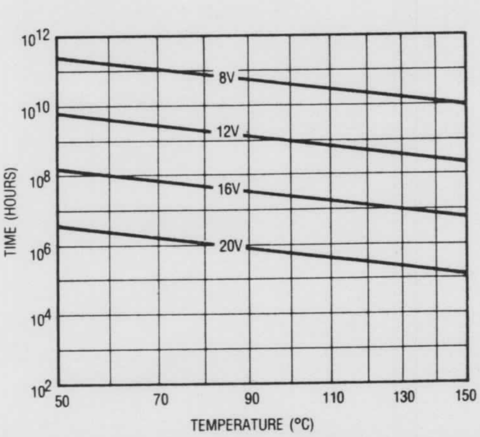


***Fig. 18 — Typical Time to Accumulated 1% Gate Failure**

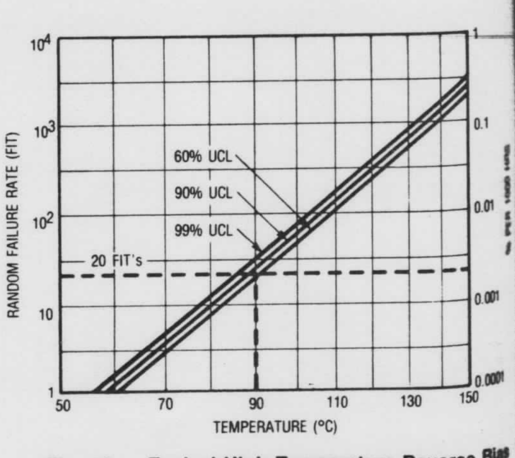


***Fig. 19 — Typical High Temperature Reverse Bias (HTRB) Failure Rate**

*The data shown is correct as of April 15, 1987. This information is updated on a quarterly basis; for the latest reliability data, please contact your local IR field office.

INT

REPETITIVE A

HEXFET®

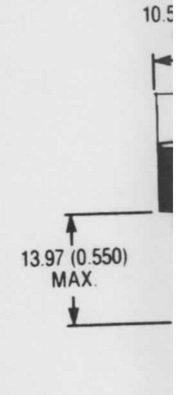
500 Volt, 3.0 Ohm H
TO-220AB Plastic Pa

The HEXFET® technolog
Rectifier's advanced line
The efficient geometry and
"State of the Art" desig
resistance combined with h
reverse energy and diode

The HEXFET transistors
established advantages
control, very fast switch
temperature stability of th

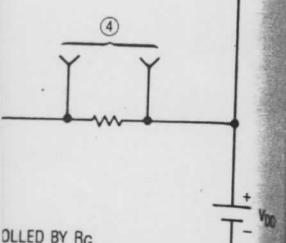
They are well suited for
power supplies, motor con
amplifiers and high ener

CASE STYLE



*This data sheet applies to produ

UIT LAYOUT CONSIDERATIONS
LOW STRAY INDUCTANCE
GROUND PLANE
LOW LEAKAGE INDUCTANCE
CURRENT TRANSFORMER



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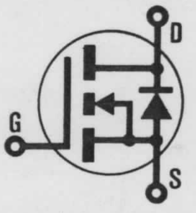
INTERNATIONAL RECTIFIER IOR

HEXFET® TRANSISTORS

N-CHANNEL POWER MOSFETs TO-247AC PACKAGE



IRFP150
IRFP151
IRFP152
IRFP153

TO-3P

100 Volt, 0.055 Ohm HEXFET TO-247AC (TO-3P) Plastic Package

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and great device ruggedness.

The HEXFET transistors also feature all of the well established advantages of MOSFETs such as voltage control, very fast switching, ease of paralleling, and temperature stability of the electrical parameters.

They are well suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers, and high energy pulse circuits.

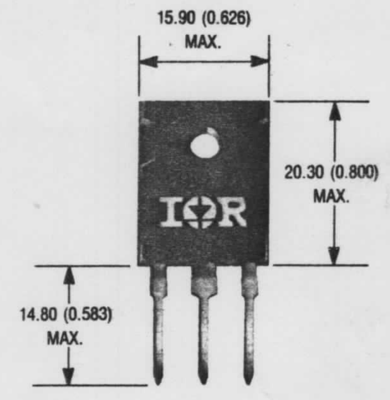
Product Summary

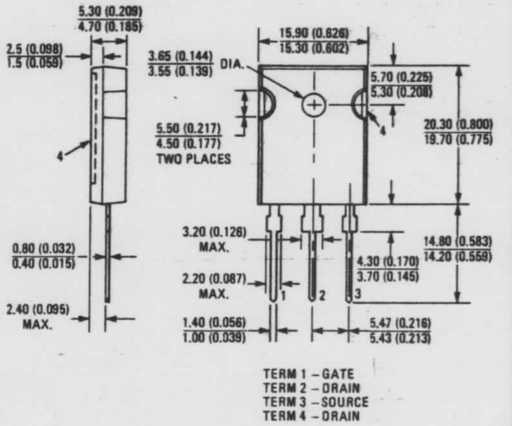
Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP150	100V	0.055Ω	40A*
IRFP151	60V	0.055Ω	40A*
IRFP152	100V	0.080Ω	34A
IRFP153	60V	0.080Ω	34A

Features:

- Isolated Central Mounting Hole
- Rugged Package Design
- Ideal for Switch Mode Power Supplies
- Low Thermal Resistance
- Fast Switching

CASE STYLE AND DIMENSIONS





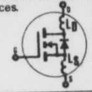
Conforms to JEDEC Outline TO-247AC (TO-3P)
Dimensions in Millimeters and (Inches)

*I_D Current limited by pin diameter

Absolute Maximum Ratings

	Parameter	IRFP150	IRFP151	IRFP152	IRFP153	Units
V_{DS}	Drain - Source Voltage ①	100	60	100	60	V
V_{DGR}	Drain - Gate Voltage (R_{GS} = 20 KΩ) ①	100	60	100	60	V
I_D @ T_C = 25°C	Continuous Drain Current ⑤	40		34		A
I_D @ T_C = 100°C	Continuous Drain Current	26		22		A
I_{DM}	Pulsed Drain Current ②	160		140		A
V_{GS}	Gate - Source Voltage	±20				V
P_D @ T_C = 25°C	Max. Power Dissipation	180				W
	Linear Derating Factor	1.4				W/K ⑥
I_{LM}	Inductive Current, Clamped	(See Fig. 14) L = 100μH 170		140		A
I_L	Unclamped Inductive Current (Avalanche Current) ③	5.9 (See Fig. 15)				A
T_J T_{stg}	Operating Junction and Storage Temperature Range	−55 to 150				°C
	Lead Temperature	300 (0.063 in. (1.6mm) from case for 10s)				°C

Electrical Characteristics @ T_C = 25°C (Unless Otherwise Specified)

	Parameter	Type	Min.	Typ.	Max.	Units	Test Conditions	
BV_{DSS}	Drain - Source Breakdown Voltage	IRFP150 IRFP152	100	–	–	V	V_{GS} = 0V	
		IRFP151 IRFP153	60	–	–	V	I_D = 250 μA	
$V_{GS(th)}$	Gate Threshold Voltage	ALL	2.0	–	4.0	V	V_{DS} = V_{GS}, I_D = 250 μA	
I_{GSS}	Gate-Source Leakage Forward	ALL	–	–	500	nA	V_{GS} = 20V	
I_{GSS}	Gate-Source Leakage Reverse	ALL	–	–	−500	nA	V_{GS} = −20V	
I_{DSS}	Zero Gate Voltage Drain Current	ALL	–	–	250	μA	V_{DS} = Max. Rating, V_{GS} = 0V	
			–	–	1000	μA	V_{DS} = Max. Rating × 0.8, V_{GS} = 0V, T_C = 125°C	
$I_{D(on)}$	On-State Drain Current ④ ⑤	IRFP150 IRFP151	40	–	–	A	V_{DS} > $I_{D(on)}$ × $R_{DS(on)max.}$, V_{GS} = 10V	
		IRFP152 IRFP153	34	–	–	A		
$R_{DS(on)}$	Static Drain-Source On-State Resistance ④	IRFP150 IRFP151	–	0.045	0.055	Ω	V_{GS} = 10V, I_D = 22A	
		IRFP152 IRFP153	–	0.060	0.080	Ω		
g_{fs}	Forward Transconductance ④	ALL	13	20	–	S (℧)	V_{DS} = 2 × V_{GS}, I_{DS} = 20.5	
C_{iss}	Input Capacitance	ALL	–	2400	3000	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1.0 MHz See Fig. 10	
C_{oss}	Output Capacitance	ALL	–	1000	1500	pF		
C_{rss}	Reverse Transfer Capacitance	ALL	–	200	300	pF		
$t_{d(on)}$	Turn-On Delay Time	ALL	–	16	24	ns	V_{DD} = 50V, I_D ≈ 38A, R_G = 6.8Ω, R_D = 1.3Ω See Fig. 16 (MOSFET switching times are essentially independent of operating temperature.)	
t_r	Rise Time	ALL	–	140	210	ns		
$t_{d(off)}$	Turn-Off Delay Time	ALL	–	59	89	ns		
t_f	Fall Time	ALL	–	92	140	ns		
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	ALL	–	73	110	nC	V_{GS} = 10V, I_D = 38A, V_{DS} = 0.8 Max. Rating. See Fig. 17 for test circuit. (Gate charge is essentially independent of operating temperature.)	
Q_{gs}	Gate-Source Charge	ALL	–	18	–	nC		
Q_{gd}	Gate-Drain ("Miller") Charge	ALL	–	27	–	nC		
L_D	Internal Drain Inductance	ALL	–	5.0	–	nH	Measured from the drain lead, 6 mm (0.25 in.) from package to center of die.	Modified MOSFET symbol showing the internal device inductances. 
L_S	Internal Source Inductance	ALL	–	13	–	nH	Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.	

Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	–	–	0.70	K/W ⑥	
R_{thCS}	Case-to-Sink	ALL	–	0.10	–	K/W ⑥	Mounting surface flat, smooth, and greased.
R_{thJA}	Junction-to-Ambient	ALL	–	–	40	K/W ⑥	Typical socket mount
	Mounting Torque	ALL	–	–	10	in. • lbs.	Standard 6-32 screw

Source-Drain Diode Ratings and Characteristics

I_S	Continuous Source Current (Body Diode)	IRFP150 IRFP151	–	–	40	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier. 
		IRFP152 IRFP153	–	–	34	A	
I_{SM}	Pulse Source Current (Body Diode) ③	IRFP150 IRFP151	–	–	170	A	
		IRFP152 IRFP153	–	–	140	A	
V_{SD}	Diode Forward Voltage ②	ALL	–	–	2.5	V	T_C = 25°C, I_S = 41A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	ALL	98	220	530	ns	T_J = 25°C, I_F = 38A, dI_F/dt = 100A/μs
Q_{RR}	Reverse Recovered Charge	ALL	0.41	0.97	2.5	μC	T_J = 25°C, I_F = 38A, dI_F/dt = 100A/μs
t_{on}	Forward Turn-on Time	ALL	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by L_S + L_D.				

① T_J = 25°C to 150°C.

② Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Fig. 5).

③ @ V_{dd} = 25V, T_j = 25°C, L = 100 μH, RG = 25Ω

④ Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%.

⑤ I_D current limited by pin diameter

⑥ K/W = °C/W
W/K = W/°C

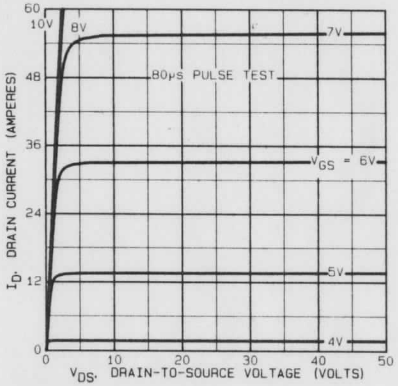


Fig. 1 – Typical Output Characteristics

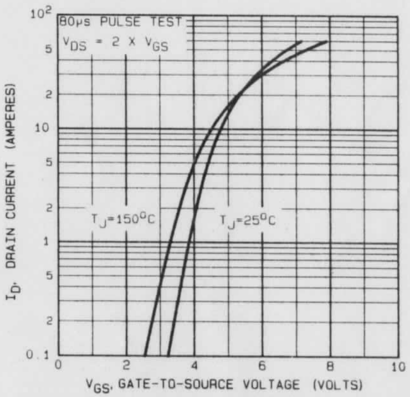


Fig. 2 – Typical Transfer Characteristics

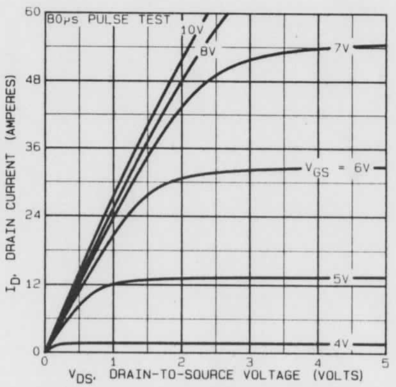


Fig. 3 – Typical Saturation Characteristics

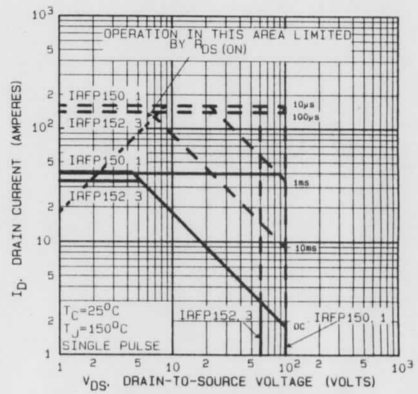


Fig. 4 – Maximum Safe Operating Area

TO-3P

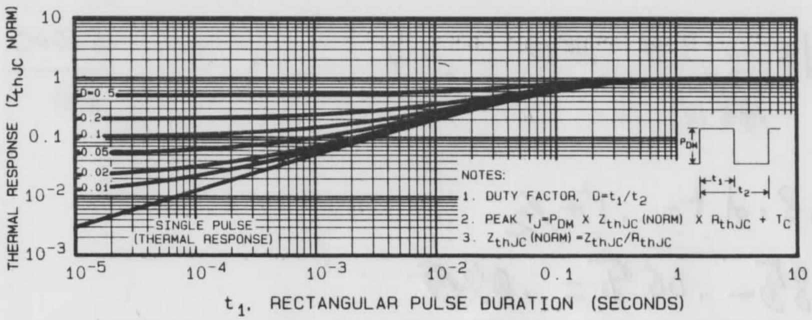


Fig. 5 – Maximum Effective Transient Thermal Impedance, Junction-to Case Vs. Pulse Duration

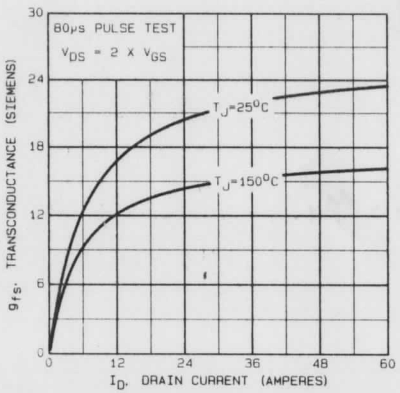


Fig. 6 – Typical Transconductance Vs. Drain Current

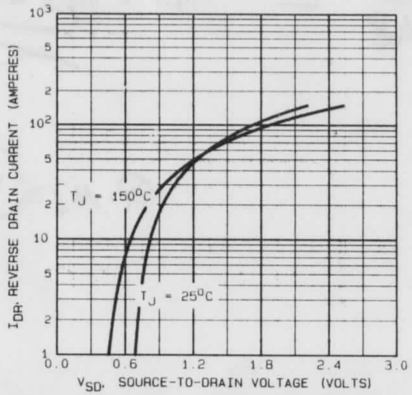


Fig. 7 – Typical Source-Drain Diode Forward Voltage

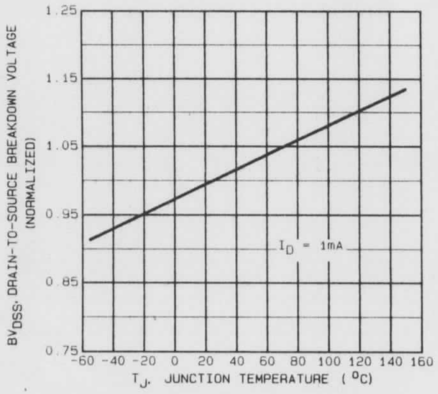


Fig. 8 – Breakdown Voltage Vs. Temperature

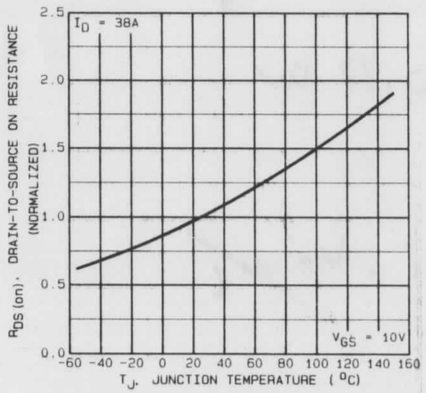


Fig. 9 – Normalized On-Resistance Vs. Temperature

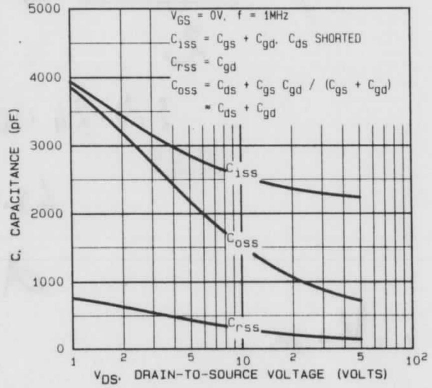


Fig. 10 – Typical Capacitance Vs. Drain-to-Source Voltage

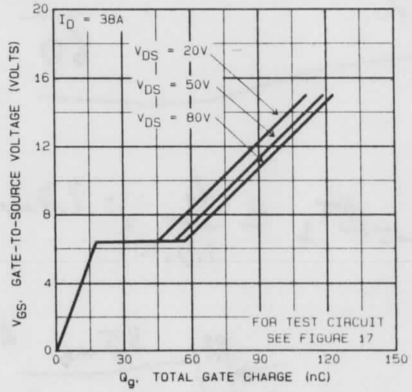


Fig. 11 – Typical Gate Charge Vs. Gate-to-Source Voltage

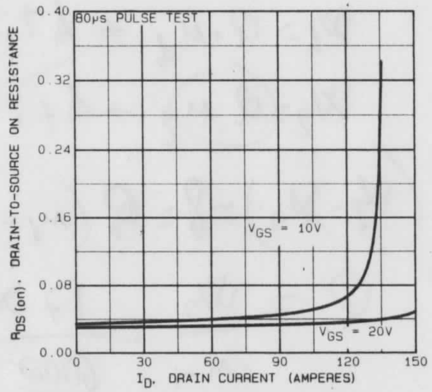


Fig. 12 – Typical On-Resistance Vs. Drain Current

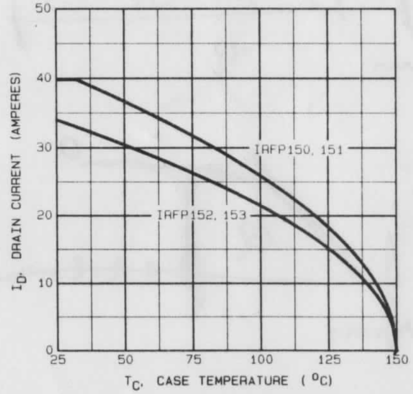


Fig. 13 – Maximum Drain Current Vs. Case Temperature

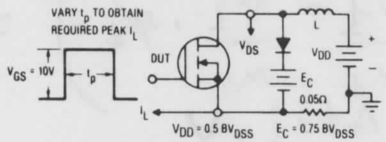


Fig. 14a – Clamped Inductive Test Circuit

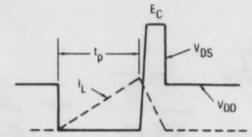


Fig. 14b – Clamped Inductive Waveforms

TO-3P

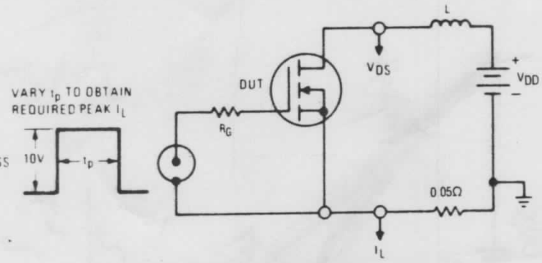


Fig. 15a — Unclamped Inductive Test Circuit

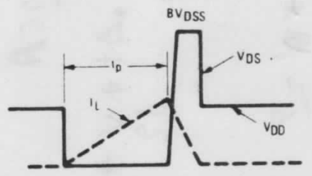


Fig 15b. — Unclamped Inductive Load Test Waveforms

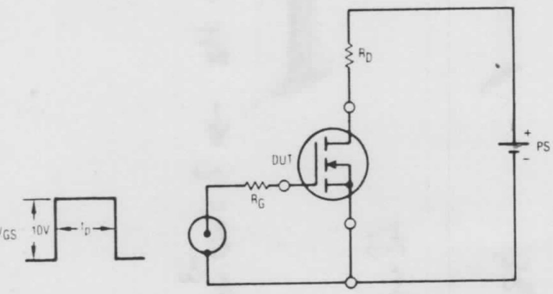


Fig. 16 – Switching Time Test Circuit

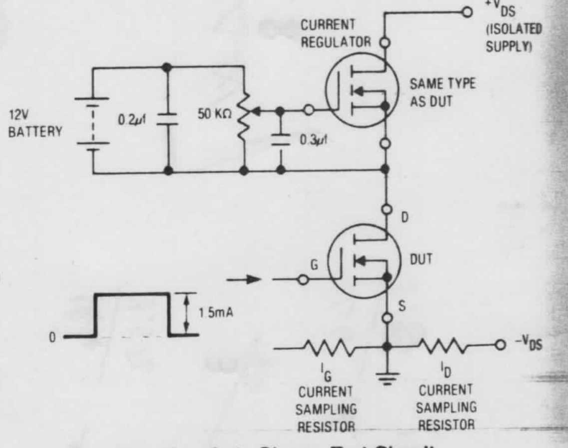
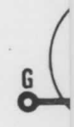


Fig. 17 — Gate Charge Test Circuit

IN

REPETITIVE
HEXFET



200 Volt, 0.18 Ohr
TO-247AC (TO-3P)

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Rectifier's advanced line
The efficient geometry an
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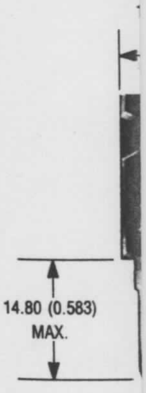
resistance combined with
reverse energy and dioc

The HEXFET transistor
established advantages
control, very fast switc
temperature stability of

They are well suited for
power supplies, motor co
amplifiers and high ene

CASE STYLE



*This data sheet applies to produc